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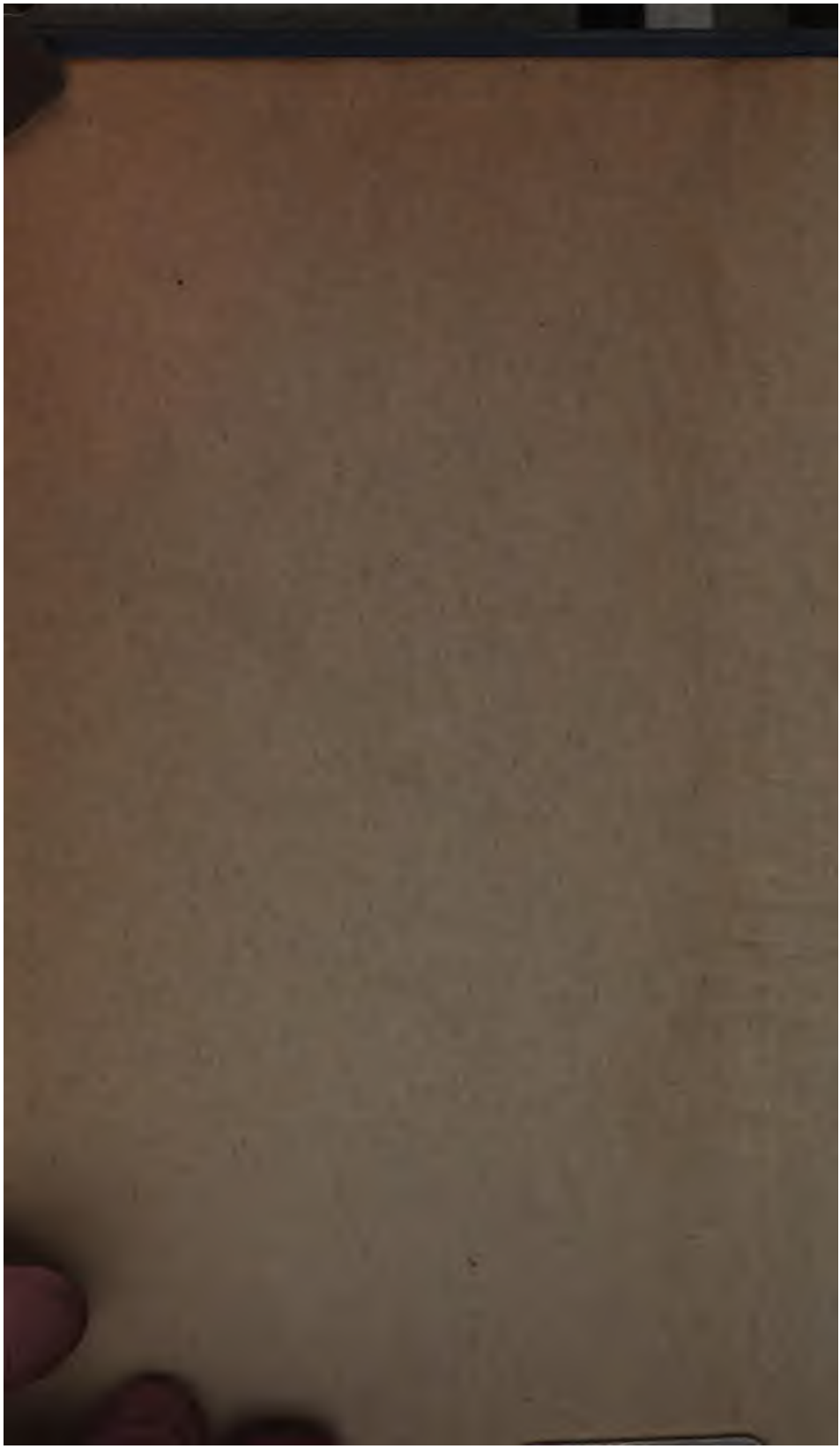

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REPORT

ON

EUROPEAN DOCK-YARDS,

BY

NAVAL CONSTRUCTOR PHILIP HICHBORN, U. S. N.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1886.

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EUROPEAN DOCK-YARDS.

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ORDERS AND LETTER OF TRANSMITTAL.

NAVY DEPARTMENT,
Washington, June 2, 1884.

SIR: It is believed that the interests of the naval service can be materially advanced and much valuable information obtained by sending a competent naval constructor to Europe to make a tour of the dock-yards of England, France, Germany, and Italy, for the purpose of observing personally the improvements in naval architecture, particularly in the construction of steel vessels of war.

The Department has selected you for this special service, and you will proceed to New York, and thence by steamship to England, and make the best and most profitable use of your time in visiting the important Government and private dock-yards, first obtaining permission from the appropriate authorities in each case, and examining the improved classes of vessels completed, or in process of construction. You will closely observe the arrangements and tools for ship-building, and the fact that the navy-yards of the United States may in the near future require to be fitted with the most modern tools and appliances for steel-ship construction makes it important that you should give considerable attention to that subject, collecting such information on this, and all other matters connected with your branch of the service, as you can with propriety.

You will carefully note all your observations, and on your return to the United States, which should not be later than October of this year, you will make a general report of the results of your visit.

You are desired to acquaint our ministers to England, France, Germany, and Italy, as well as all other representatives of the United States at the places you may officially visit, with the object of your tour, and ask their kind offices in aiding you as far as possible in securing admission to the establishments which it may be desirable to visit, and such facilities as can be conveniently and properly extended.

Your actual expenses will be allowed while absent from the United States in carrying out these instructions, and you will keep an accurate account of your expenses, taking vouchers where you can conveniently obtain them, and render an account to the Fourth Auditor of the Treasury on your return.

Very respectfully,

WM. E. CHANDLER,
Secretary of the Navy.

Naval Constructor PHILIP HICHBORN, U. S. N.,
Navy-Yard, League Island, Pa.

NAVY DEPARTMENT.
BUREAU OF CONSTRUCTION AND REPAIR.
Washington, June 2, 1884.

SIR: The honorable Secretary of the Navy has sent your orders to the Bureau, for its information, with instructions to forward them to you, which duty the Bureau performs with pleasure, believing that you will execute the duty imposed upon you with credit to yourself and profit to the naval service.

Wishing you a pleasant and successful trip and a safe return, I am, very respectfully, your obedient servant.

T. D. WILSON,
Chief of Bureau.

Naval Constructor P. HICHBORN, U. S. N.,
Navy-Yard, League Island, Pa.

NAVY DEPARTMENT.
BUREAU OF CONSTRUCTION AND REPAIR,
Washington, D. C., June 9, 1884.

SIR: While abroad, the Bureau requests that whenever it is possible to obtain plans and specifications of vessels of modern type, whether as a whole or of any details, together with photographs of work in detail, or vessels completed, showing their fittings, &c., you will make arrangements to have them sent to the American dispatch agent for payment and transmission to the Bureau; or, if you deem it best, you can communicate with the Bureau and let it order them direct.

You should gather all information possible relative to improved tools for steel and iron ship-building, getting plans of tools when possible to do so, even though they may have to be purchased, and obtaining all the illustrated circulars with prices that you can. Should you have an opportunity so to do, ascertain the number and kinds of tools used in the best-fitted dock-yards, both public and private, in the several countries you will visit, and somewhere near the value of such a complete plant. Such tools as can only be had by manufacturing them to order, you will ascertain the price at which they can be contracted for, and the time required to prepare and ship them.

There will undoubtedly be many things that you will see in the course of your travels which it would be to the best interests of the Bureau to have, or to know where to obtain. In this matter the Bureau relies upon your known good judgment to decide what is best to be done, without losing time by having to communicate with it.

Very respectfully, &c.,

T. D. WILSON,
Chief of Bureau.

Naval Constructor PHILIP HICHBORN, U. S. N.

NAVY DEPARTMENT,
Washington, August 15, 1884.

SIR: The Department's order of June 2 last, directing you to make a tour of the dock-yards of England, Germany, and Italy, are so modified that you will proceed to Russia in place of Italy; and, on your return, you will avoid the cholera districts as much as possible.

Very respectfully, WM. E. CHANDLER,
Secretary of the Navy.

Constructor PHILIP HICHBORN, U. S. N.,
London, England.

LETTER OF TRANSMITTAL.

Washington, October 12, 1885.

SIR: In obedience to the foregoing orders, I have completed a tour of some of the principal public and private dock-yards of Europe, and respectfully submit the following report:

After arriving in Liverpool and visiting the docks, which constitute the most interesting feature of the second city of Great Britain, I proceeded to London, and studied the ship-building industry of the Thames.

While my application to visit Her Majesty's dock-yards was being forwarded, I went to Sheffield and saw the manufacture of compound armor, as produced by the systems of Cammell and Brown. I then visited Newcastle and the private works on the Tyne.

Glasgow was my next center of observation, and in the body of my report will be found the result of numerous visits to the yards of the Clyde, and to the leading makers of ship-building tools in that district. I next crossed to Belfast, Ireland, and saw the fine yard of Messrs. Harland & Wolff, and then proceeded through Wales to Pembroke, and returned to London, stopping in succession at the several dock-yards of Devonport, Keyham, and Portsmouth.

After visiting Chatham and Sheerness, I departed for the Continent, and visited the German establishment at Kiel, and thence proceeded to St. Petersburg. I came back by way of Paris, examining there the excellent naval collection of the Louvre, and devoting some attention to the system of education for naval constructors in the Ecole Polytechnique. Lorient, Brest, and Cherbourg were then visited, and I returned to England and then to the United States.

At the suggestion of the Bureau, and by the politeness of the Hon. Secretary of the Navy, Draftsman F. B. King was ordered to report to me for duty in connection with my tour. Since my return he has been of great assistance to me in the preparation of my report; and has performed his duties, both at home and abroad, to my entire satisfaction. His services in the future will be of much value to the Government from the knowledge gained.

In conclusion, it gives me great pleasure to recur to the courtesies received from many sources during this tour, which have added greatly to its enjoyment, and, I trust, to its usefulness as well. Of these attentions, so numerous and kind, I prefer to mention none in particular; because I should inevitably omit many deserving my most sincere acknowledgment. I found in every country which I visited, the most gratifying respect awarded to our national character, and a disposition to forward my professional labors, which I shall long remember as one of the most pleasant features of the tour.

I have, sir, the honor to subscribe myself your obedient servant,

PHILIP HICHBORN,
Naval Constructor, U. S. Navy.

Chief Constructor THEODORE D. WILSON, U. S. N.,
Navy Department, Washington, D. C.

NATIONAL DOCK-YARDS.

GREAT BRITAIN.

ome dock-yards of Great Britain are Chatham, Sheerness, Ports- Devonport and Keyham, and Pembroke. Some of these yards en laid out under great engineering difficulties and at enormous e, notwithstanding the fact that much of the labor, such as re- ion and brick-making, has been done by convicts. The total f the above-named yards was returned on March 31, 1884, at ,570, under the following heads: Land, $2,324,725; buildings, ng slips, basins, storehouses, and shops, $55,121,700; machinery , $6,238,145. To this should be added timber and other ma- for ship-building and the outfit of vessels, amounting to about ,000, making a grand total of $75,000,000 represented in the dock- alone. About 18,000 men were employed throughout the year, ir average pay per day was $1.03.

policy of the British Admiralty is to utilize the yards to their extent; and, while all the machinery for the ships is supplied by firms, nearly two-thirds of the ship-building and all the repairs e at the national yards. The total sum expended in the fifteen etween April 1, 1869, and April 1, 1884, upon new building and of vessels of the royal navy aggregates $179,649,625, to which add ,650 for incidental and establishment charges, making a grand f $217,395,275, or twenty-eight one hundredths of the total appropriation during the same period. Of this armored ves- ilt in dock-yards aggregated $46,078,105; unarmored vessels, ,010, against contract built at $21,035,290 and $23,115,285 re- ely; thus indicating that while $44,150,575 were expended on t work, $173,244,700, or four-fifths of the sum appropriated for g and repairs was alloted to the dock-yards.

PEMBROKE DOCK-YARD.

ette ships *Anson* and *Howe;* partially protected cruisers *Thames* and *Forth.*)

best adapted of the British dock-yards for building operations is oke. It comprises 77 acres, and has eleven building slips, which ered by substantial ship-houses. Having but one dock, no basins, w shops and stores, it is not a fitting-out yard, and can only be ed so at very great expense. Vessels built there usually go to uth, Portsmouth, or Chatham to complete.

THE ANSON.

ships of the British Admiral class, the Anson and the Howe, were construction at the time of my visit. Both were well advanced, e latter was being made ready for launching.

The Anson is 330 feet long, 68 feet 6 inches beam, and 26 feet 2 inches hold. Her displacement will be 10,000 tons on a load draught of 26 feet 9 inches. The engines are vertical, turning-twin screws, and will indicate 7,500 horse-power, and be capable of developing with forced draft 9,500 horse-power and a speed of 16 knots. She will carry four 13½-inch 63-ton B. L. R. guns, disposed in two barbettes, one placed forward and the other aft. The barbettes are pear-shaped, and between them extends a superstructure in which six 6-inch guns are mounted. The ends of the superstructure are protected by 6-inch compound armor, but the sides are unprotected. The barbettes are built up of sections of steel-faced armor from 12 to 14 inches in thickness, placed at a large inclination from a vertical line.

The armor on the water-line and citadel is 18 and 16 inches in thickness. ver the citadel an armor deck 3 inches in thickness extends, and over the forward and after parts of the ship there is a similar deck 2½ inches thick. Armored tubes, or trunks, 12 inches thick and about 7 feet in diameter, connect the barbettes with the spaces below this deck and protect the hydraulic elevators by which ammunition is passed up to the large guns. In addition to the armament already mentioned, twelve 6-pounder quick-firing shell guns, eight Nordenfeldts, and two Gardner guns will be carried; there will also be twelve Whitehead torpedoes, which are to be discharged from four torpedo ports on the main deck. The coal capacity is 1,200 tons, and the estimated cost is £581,000.

THE HOWE.

The Howe is of slightly smaller dimensions than the Anson. Her length is 325 feet; breadth, 68 feet; and the displacement 9,700 tons on a draught of 26 feet 9 inches. The armament and indicated horse-power are identical in the two ships. They are built wholly of steel, and the same plan of construction is carried out in both.

The frame may be divided into five portions: That forward and abaft of the double bottom, which is comparatively simple and resembles that of an ordinary merchant ship; that within the double bottom; that extending from the wing-plate of the double bottom to the armor shelf; that in the wake of the armor; and that above the armor.

Within the double bottom a series of longitudinals extend uninterruptedly forward and aft, cutting off all the frames and reverse bars. In constructing this portion the brackets and plate frames are built out, section after section, their outer ends resting temporarily upon ribands, by which the shape is retained until the longitudinals are inserted and rivetted up.

Forward and abaft the double bottom the longitudinals taper into ordinary keelsons, and the frames are of Z-bars, $6'' \times 3\frac{1}{2}'' \times 3'' \times 14$ pounds, spaced 3 feet apart. Within the water bottom the frame space is 4 feet. From the wing-plate to the armor shelf there are deep web frames, spaced 4 feet apart, and in the wake of the armor Z-bars $10'' \times 3\frac{1}{2} \times 3\frac{1}{2}'' \times 20$ pounds are used at intervals of 2 feet. Above the side armor the principal frames are $7'' \times 3'' \times 12$-pound angles, 4 feet apart, with an intermediate frame $4'' \times 3'' \times 8$ pounds.

The armor deck is constructed with a flat portion in the center, from which it descends with a very gentle slope to the sides and lands on the armor, to which it is securely tapped. Forward and abaft of the side armor the deck, maintaining the same cross-section, descends to the ram and the stern-post, and attaches to the side plating at the edges by two stout angles, one above and one below, both legs of the angles being

HOWE.

double rivetted. With a view to making the plating below this deck secure from injuries which may occur to the parts above, the plating is cut off, in the wake of the armor deck, and a strip of steel about 3 inches in width is inserted.

A multiplicity of water-tight compartments is a conspicuous feature in these vessels, there being sixteen in the double bottom; and, in addition to numerous athwartship bulk-heads, a longitudinal center bulk-head, running through the middle of the ship and rising to a height of 6 feet 6 inches above the water-line.

I found the Howe sufficiently advanced to receive some of her joiner work. With a view to making the skin of the ship perfectly accessible from the inside, the ceiling was being worked in panels and secured by screws in such a way that the interior can easily be inspected.

The weight of hull, including armor and backing, is 6,640 tons for the Anson, and 6,330 for the Howe, and the estimated cost of hull and fittings is £475,000 for the former and £440,000 for the latter, or about £70 per ton of weight.

THE THAMES.

The Thames and Forth, twin screw protected cruisers of the Mersey class, which latter is a development of the Leander in the direction of additional protection, were also building here. They are of 3,550 tons displacement, 6,000 indicated horse-power, and will carry two 8-inch 13-ton and ten 6-inch guns, all breech-loaders. There are also a number of machine-gun towers distributed along the side. In the Leander class the protective deck is but 1½ inches in thickness, and it extends only over the machinery spaces; in the Mersey class it runs from end to end, and is composed of two 1-inch layers over the crown, which is nearly flat, and three 1-inch layers on the sloping sides. It cuts the framing entirely off, and is supported on angle bulbs, one on every frame.

A double bottom extends throughout the engine and boiler spaces, of a construction similar to that of the Anson and Howe, already described. The water-tight connection of the inner bottom to the side, however, is made by bending down the inner plate and attaching it to the skin by a continuous angle, the frames being entirely cut off and dependent on a gusset for their attachment to the wing plate.

Forward and aft of the double bottom the longitudinals become intercostals. The frames throughout are **Z** bars, and this shape is much used in the keelsons also. There is a poop and forecastle and a high waist extending between them. A frame of light beams covers the deck from end to end, and is utilized for the stowage of boats, spare spars, and other purposes. The rig is of the simplest description; two steel masts with military tops and a small spread of fore-and-aft sail.

DEVONPORT AND KEYHAM.

(Composite sloops of the *Mariner* class, the *Royalist;* a specimen troop-ship, the *Amphion.*)

The dock-yards of Devonport and Keyham are really one. They contain in the aggregate 140 acres, and are connected by a tunnel through which a railway has been laid, and locomotives belonging to the yards transfer materials and men from one to the other. The accompanying plan will give a better idea of the yards than an extended description. Keyham has received most of the recent improvements and is

more modern than Devonport; and in addition to its excellent shops it has extensive fitting-out basins, provided with every facility for transporting and hoisting heavy weights. The building slips and most of the dry docks are located in the Devonport yard. One of the latter has just been completed; it is of excellent masonry, but has the precipitous sides and general inaccessibility which seems inseparable from European dry-docks. There is also a large floating platform worked in connection with the dry docks, intended to be submerged and used to float out vessels while under repair. It has been but little employed, and was not recommended by the constructors.

COMPOSITE SLOOPS.

In the Devonport yard three small composite vessels were building. These were the Mariner, Racer, and Icarus, single-screw ships of 950 tons displacement, carrying two 6-inch breech-loading rifles and two 5-inch. The dimensions of these vessels are: Length between perpendiculars, 167 feet; breadth, extreme, 32 feet; breadth, molded, 31 feet. Their draught is 11 feet 6 inches forward and 14 feet aft, with a freeboard of 6 feet. The engines will be horizontal, compound, surface-condensing, 32″ and 54″ by 36″ stroke, supplied with steam by three boilers, 7 feet 2 inches diameter and 16 feet 9 inches long. Ninety pounds of steam will be carried, and the engines are to indicate 890 horse-power.

A brief outline of the construction of these vessels is as follows: There is a flat keel-plate of three-eighths-inch steel, 21 inches wide amidships. To this is attached, by three-fourths-inch copper bolts, an English elm keel, siding 12 inches. The stem is a similar combination of wood and steel, the plate being flanged to receive the hoods. There is an intercostal center keelson, which ends forward in a vertical plate attached to the stem by double angles. The rudder-post is of oak, siding 11½ inches. A composition shoe connects the posts to each other and to the keel of the vessel. The rudder is of wood and has a composition stock. Wherever steel comes in contact with oak a facing of teak is interposed to prevent corrosion. The transverse frames are 20 inches from center to center throughout the vessel, and are of Z bars, 6½″ × 3½″ × 3″ × 15 pounds per foot. Up to the turn of the bilge they are split and worked at the top and bottom of an ordinary floor-plate, which is of 12½ pounds per square foot. The floor-plates are continuous across the center keelson. Every other frame, where it passes through the upper deck, is reduced so as to form a 4″ by 3½″ angle in the wake of the waist. This is also the case in the poop and forecastle. Sheer-strakes are worked on the forecastle and poop and along the upper deck; the latter are 18 inches wide and 15 pounds per square foot.

The teak planking is put on in two thicknesses, breaking joints all the way forward and aft. The garboard strake is in one thickness of English elm. The fastenings of the inner thickness are of three-fourths-inch naval brass screw-bolts, tapped through the frames and having a nut on the inside. The diameter of these bolts is increased one-sixteenth inch above the thread. They are made of 62 parts of best selected copper, 37 of Silesian zinc, and 1 of tin. They are tested by being bent cold to an angle of 40 degrees. Any slacking back of the nuts is prevented by center-punching the threads after heaving up. The outer thickness is fastened to the inner by one-half-inch copper bolts riveted on the inside on composition rings. The heads of the inside fastenings are kept five-eighths inch inside of the outer surface of the plank, and those of

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the outer fastenings one-eighth inch inside. Both are set in a mixture of white and red lead. The recessed heads of the inner bolts are plugged with the same mixture and those of the outer with a special compound. The iron and steel against which the wood bears, as well as the faying surfaces of the two thicknesses of plank, are well coated with a mixture of white and red lead. A carefully-arranged shift of butts for the two layers is prepared, and no planks less than 20 feet in length are used except the hoods.

The planking of the topsides is worked in a single thickness of teak, except the round portion at the stern, which is of Honduras mahogany. The inside of the waist is ceiled with thin steel.

All of the transverse bulk-heads are built of steel. They attach to the skin by single angles, 3″ by 3″. The coal-bunkers, shaft-alley, &c., are all constructed of steel.

THE ROYALIST.

A larger composite vessel, the single-screw corvette Royalist, of 1,420 tons displacement, was nearing completion in this dock-yard. She is a fine vessel, carrying in all twelve long breech-loading rifles, one 6-inch under the forecastle, another in the cabin, and ten 5-inch on the broadsides. There is an efficient machine-gun armament, two such guns being mounted on the forecastle on low cylinders or towers, containing the red and green side-lights, which are introduced from below. The wood planking is 3½ inches inside and 3 inches outside, and the fastenings are like those already described on the Mariner a[illegible]ss. Sketches, illustrating this construction in Her Majesty's ser[illegible]re appended.

The Royalist made a six-hours' full speed c[illegible]ctor's trial trip in November, 1883, drawing 1 foot less than her load draught. The screw, 13 feet 6 inches pitch, made 107.3 revolutions, and the engine developed 1,160 horse-power, or 210 more than the contract specified. The speed by patent log was 12½ knots, although there was a stiff breeze and a rough sea during the whole trial. The vessel has since been fitted for the use of forced draft, by which the horse-power will be increased to 1,500 and the speed may exceed 13 knots.

The Amphion, of the same class as the Leander, was being completed here. Beside the foregoing ships, building and completing, some interesting repair work was going on. The Defence, one of the early British armor-clads, was in dock, having recently been damaged by collision with the Valiant. Her stem being much bent, a few of the adjacent plates were removed; a temporary furnace was built about the stem, which was heated and forced into place by hydraulic jacks.

TROOP-SHIP TAMAR.

The Tamar, one of the excellent fleet of British troop-ships, had just received extensive repairs, and her commodious arrangements and studied adaptation to the ends in view invited much attention. The plan of these large vessels is admirable, and is such as secures the maximum of comfort to both officers and men. The accommodations for the latter forward on the main deck, and on the lower deck both forward and aft, were remarkably cleanly and roomy. Iron berths are fitted, which can be arranged to unship. A separate inclosure is provided for the soldiers' wives, who are allowed, in limited numbers, to accompany their husbands. These quarters, as well as those of the officers, are lighted by incandescent lamps. The state-rooms for the officers and

their families are replete with comfort. The joiner work of the ward rooms and cabins is painted and effectively ornamented by panels o paintings placed under glass.

A peculiarly advantageous arrangement is observable on the uppe deck, where a range of state-rooms extends along both sides of th deck between the poop and the forecastle. The middle space is entirel open above, and gives the inclosures excellent ventilation. The inclos ures aft are used for state-rooms, and those forward are used for th transportation of animals. Special boats, pontons, &c., are carrie for embarking or disembarking soldiers and horses. The Inconstan was at Devonport about to undergo a complete refit.

PORTSMOUTH.

(The *Collingwood*, *Camperdown*, *Colossus*, and *Imperieuse*; details of the *Calliope*, t *Polyphemus*, *Hecla*, &c.)

The Portsmouth dock-yard, containing 115 acres, is the greatest o the British dock-yards, 5,660 employés being provided for in this year estimates, representing an expenditure in wages of £383,666. The a companying plan will show the general distribution of the basins, dock and buildings, including the extension, which is still incomplete. Th basins are now finished, with the exception of the northwestern on which is walled but has not yet been excavated. The repairing basi has lately been equipped with an 80-ton shears. The dry-docks num bered 12, 13, 14, and 15 still remain incomplete. This work of excava tion is performed by the convicts, whose prison adjoins the dock-yard When these improvements are all completed, Portsmouth yard will con tain five building slips and fifteen dry-docks, besides the long locks be tween the basins which can be used as dry-docks.

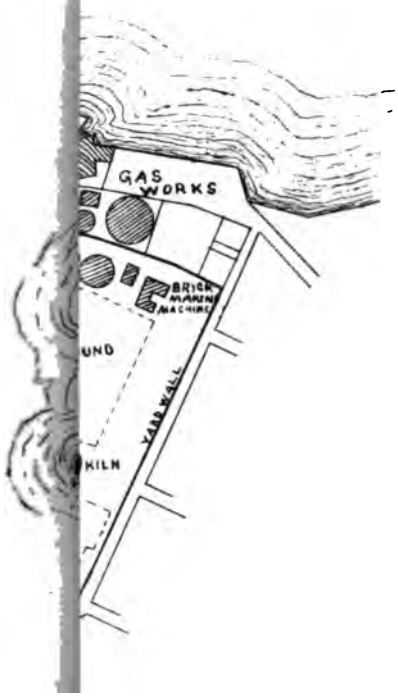
The Camperdown and Collingwood, two vessels of the Admiral class similar to the Anson and Howe, already described, were completing a the time of my visit; the latter was the more advanced, but the follow ing data will give a good idea of the stage of the work upon these ves sels in October, 1884:

THE COLLINGWOOD.

"The Collingwood is of 9,150 tons displacement, against the Camper down, of 10,000 tons, and will also carry a less formidable armament She was brought around from Pembroke, where she was built, for com pletion and to be put through a series of progressive speed trials. Th engines are by Messrs. Humphrys, and at the official trial in May 1884, they developed 9,558 horse power, under forced draft, giving th ship a speed of close upon 17 knots. Exertions are being made to ge the barbettes of the ship ready for a firing trial of her 43-ton guns in December, and, considering the progress already made, there is no rea son to doubt that the arrangements will be completed by the date fixed The work in connection with her broadside and machine gun armamen is also being pushed forward, as well as the completion of the ship gen erally. The Collingwood differs from the later ships of her class in tha she carries four 43-ton guns in her barbettes, whereas the Rodney Howe, Camperdown, and Anson will be armed with 63-ton guns, while the Benbow is intended to carry a couple of guns of the enormous weight of 110 tons each.

DOCK YARD
PORTSMOUTH ENGLAND, 1885.
SCALE OF FEET 1/7500

1. 6. 15. OFFICES
2. ARMOUR PLATE SHOP
3. SMITHERY
4. WEST FACTORY
5. WOOD MILLS
7. BRASS FOUNDRY
8. N.W. BUILDING
9. N.E. "
10 SAW PITS
11. 14. TIMBER SHEDS
12. S.W. BUILDING
15. S.E. "
16. CONTRACTOR'S YARD
17. DEAL YARD
18. ROPE HOUSE
19. 20. 21. 22. STORES
23. MAST WORKSHOP
24. 25. BOAT HOUSES
26. R.N. COLLEGE
27. MAIN GATE
28. 29. 30. OFFICERS HOUSES
31. IRON FOUNDRY
32. MARLBORO GATE
33. POLICE
34. SALT WATER TANK
35. KING'S STAIRS



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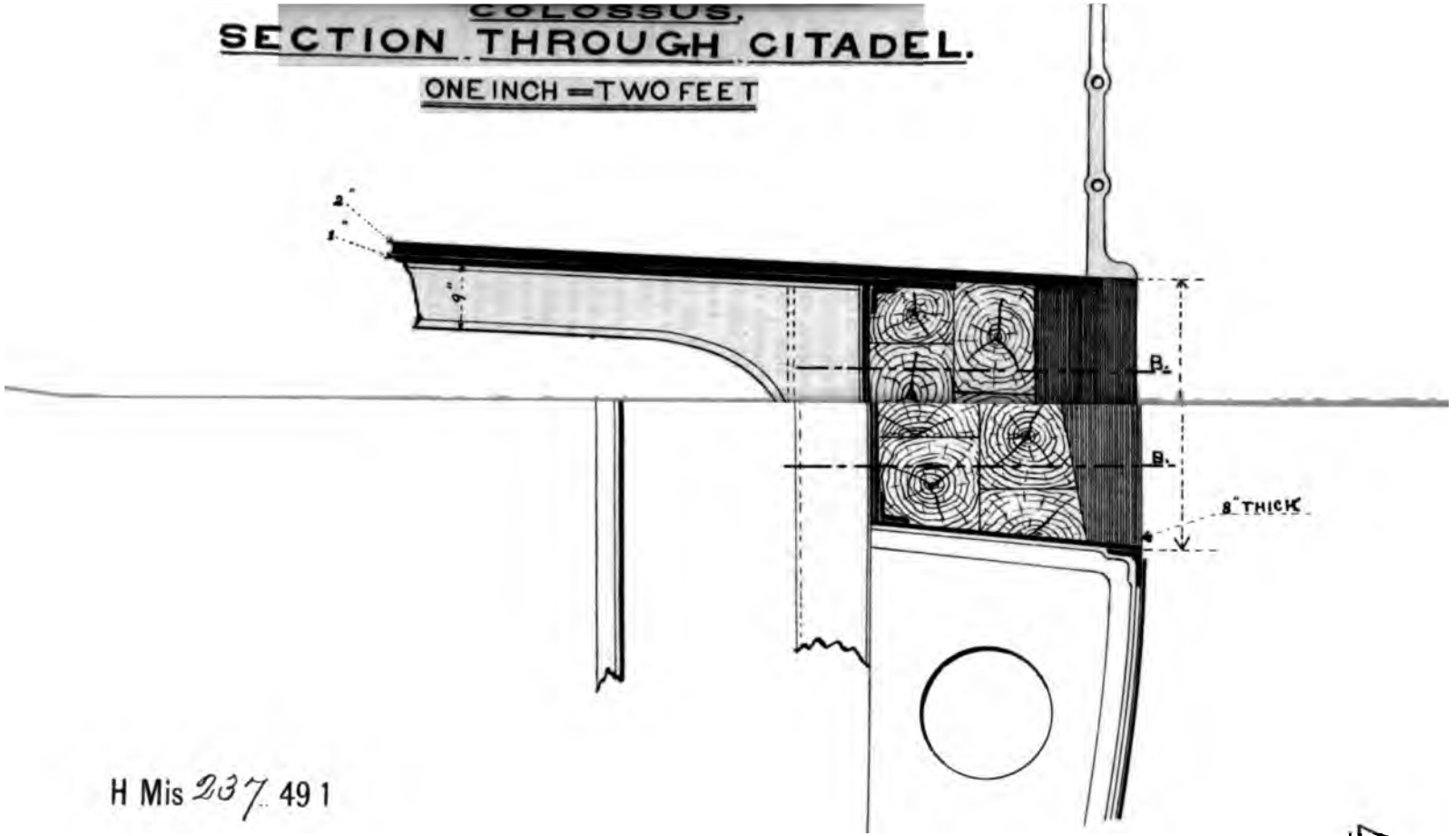

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THE CAMPERDOWN.

"The Camperdown was laid down in December, 1882. Nearly 3,000 tons of material have now been worked into the ship. She has been so far advanced that the spar-deck beams are in place, and the plating of the bow is almost finished. The whole of the side bulkheads and horizontal armor has also been fitted, while the engine and boiler rooms are practically ready to receive the propelling machinery. At the after part of the vessel the brackets are being fastened off, and the plating above the armor-deck is being closed in. An addition has been made to the stem of the ship above water to enable a torpedo to be discharged right ahead; and the formation of the side torpedo-ports, of which there are two on either side above water, is being proceeded with. The large and heavily-armored tubes to afford protection to the passage of ammunition and the loading gear are ready to receive the armor, which, with the whole of the armor-plates, has been supplied by Sir John Brown & Co., of Sheffield. The greater portion of the forty steel-faced plates, each weighing 20 tons, and forming the armor belt at the water-line, have been placed on board, and some idea may be formed of the enormous strength of one of the latest proposed additions to the armored fleet.

"The Camperdown is one of the largest of her class under construction, being 330 feet in length between perpendiculars, 68 feet 6 inches beam, and will have a displacement of 10,000 tons on a mean draught of 26 feet 9 inches. She is thus longer than the Inflexible and the Colossus, and broader than the latter; and while her displacement is 1,980 tons less than the Inflexible, her draught exceeds that of either ship. In the horse-power of her engines she will also surpass both; the contract providing for 9,800 horse-power. She is designed to steam at the rate of 16 knots per hour, and will be fitted for forced draft; and judging from the result of trials of vessels of the same class already built, the actual result will, in all probability, exceed the estimated speed.

"The armament of the ship will comprise four 63-ton guns, mounted in a couple of barbettes, and six 6-inch B. L. R. in a covered upper-deck battery, the sides of which are of 1-inch plating, while the ends are formed of armored bulkheads, composed of 6-inch plating to protect the gun crews from a fore-and-aft fire. The battery will also contain four 6-pounder quick-firing guns, and six similar guns will be mounted on the upper deck, while ten 5-barreled 1-inch Nordenfeldts will be disposed between decks in towers projecting beyond the sides of the vessel.

"The offensive powers of the Camperdown will be further increased by Whitehead torpedoes, which will be arranged to fire from four broadside positions, and from one right-ahead port cut through the upper part of the stem. The construction of the ship is of the usual type. An armored belt protects the vital parts amidships, while forward and aft there is an armored deck, about 5 feet below the water-line, and extending from the belt to the stem and stern, dividing the hull horizontally. The ends are further subdivided into several small compartments, so that should the bottom be damaged, only a small portion of the hold is likely to be filled with water. No definite period has yet been fixed for the launch, but in all probability it will take place in August, 1885."

THE EDINBURGH AND COLOSSUS.

The Edinburgh, formerly known as the Majestic, a turret ship of 9,150 tons displacement and 6,000 indicated horse-power, was in one of the docks. Little was being done on her, as she was awaiting the comple-

tion of her sister ship the Colossus. These vessels are of the Inflexible type, having the echelon arrangement of turrets, with a central superstructure extending forward and aft. They carry four 43-ton B. L. R. guns in the turrets, and five 6-inch 4½-ton breech-loaders, upon Vavasseur mounts, with protecting shields. The 43 ton gun fires a projectile of 700 pounds, with a powder charge of 400 pounds, and gives a muzzle energy of 2,200 foot-tons.

The length of these ships is 325 feet; breadth, 68 feet; mean draught, 26 feet. The water-line armor is 18-inch steel faced; that on the turrets is 14-inch. Sketches are appended, showing the side armor and the disposition of the internal coffer-dams and cork chambers in the unarmored ends. The estimated speed is 16 knots. The Edinburgh was launched at Pembroke in 1882, having been about three years on the stocks. With the exception of the guns and the torpedo battery, about which there is some delay, both ships may be said to be completed. The mode of managing the breech-plug of the large guns has been under advisement since the ships were laid down, and until very lately was still undetermined. That contemplated is said to be something novel and unique. The fittings of the magazines and the ammunition elevators are also in abeyance.

The cabins are made of thin steel, not covered with wood, but merely trimmed with light moldings around the blinds and ventilating apertures.

The engines of the Colossus, built by Messrs. Maudslay, Sons & Field, were given their six hours' trial on the 10th of January, 1884, developing a mean indicated horse-power of 7,514. There are two three-cylinder compound engines, 58″ and 74″, and 74″ by 39″ stroke. The shafts are hollow, and are made of Whitworth's fluid-compressed steel. The propellers are four-bladed, of manganese bronze, 17 feet 6 inches diameter, and 18 feet 6 inches pitch. The boilers are disposed in four water-tight fire-rooms, and represent a grate surface of 650 square feet. The working pressure is 60 pounds. The mean speed was 16½ knots. There is bunker capacity for six days' full steaming, or 2,343 knots.

Sir Thomas Brassey has spoken of these ships as "reduced Inflexibles." Though smaller and of similar design, they possess several advantages over the more powerful iron-clads. They have higher speed by almost 3 knots. Their 43-ton breech-loaders are not considered much inferior to the 81-ton muzzle-loaders, and in light guns the new ships have the superiority. They carry ten Nordenfeldt and four Gardner machine guns. In the matter of torpedoes the Inflexible is better equipped, having seven discharging tubes as against two on the Colossus and Edinburgh.

There are now five ships of this type in the British navy. Immediately upon the launch of the Inflexible, in 1876, the Ajax and Agamemnon, smaller vessels of the same general design, were begun. Their armor ranged from 14 to 18 inches, and their large guns were 38-ton M. L. R. The Colossus and Edinburgh followed, and take rank between the Ajax and Inflexible. They have less power than the Collingwood, although their displacement is as great.

THE IMPERIEUSE.

The Imperieuse, a twin-screw barbette cruiser, of 7,390 tons and 8,000 indicated horse-power, was also completing in one of the docks. She is 315 feet long; 61 feet beam, molded, and 62 feet extreme; depth of hold, 23 feet 11 inches; draught forward, 24 feet 5 inches; aft, 2

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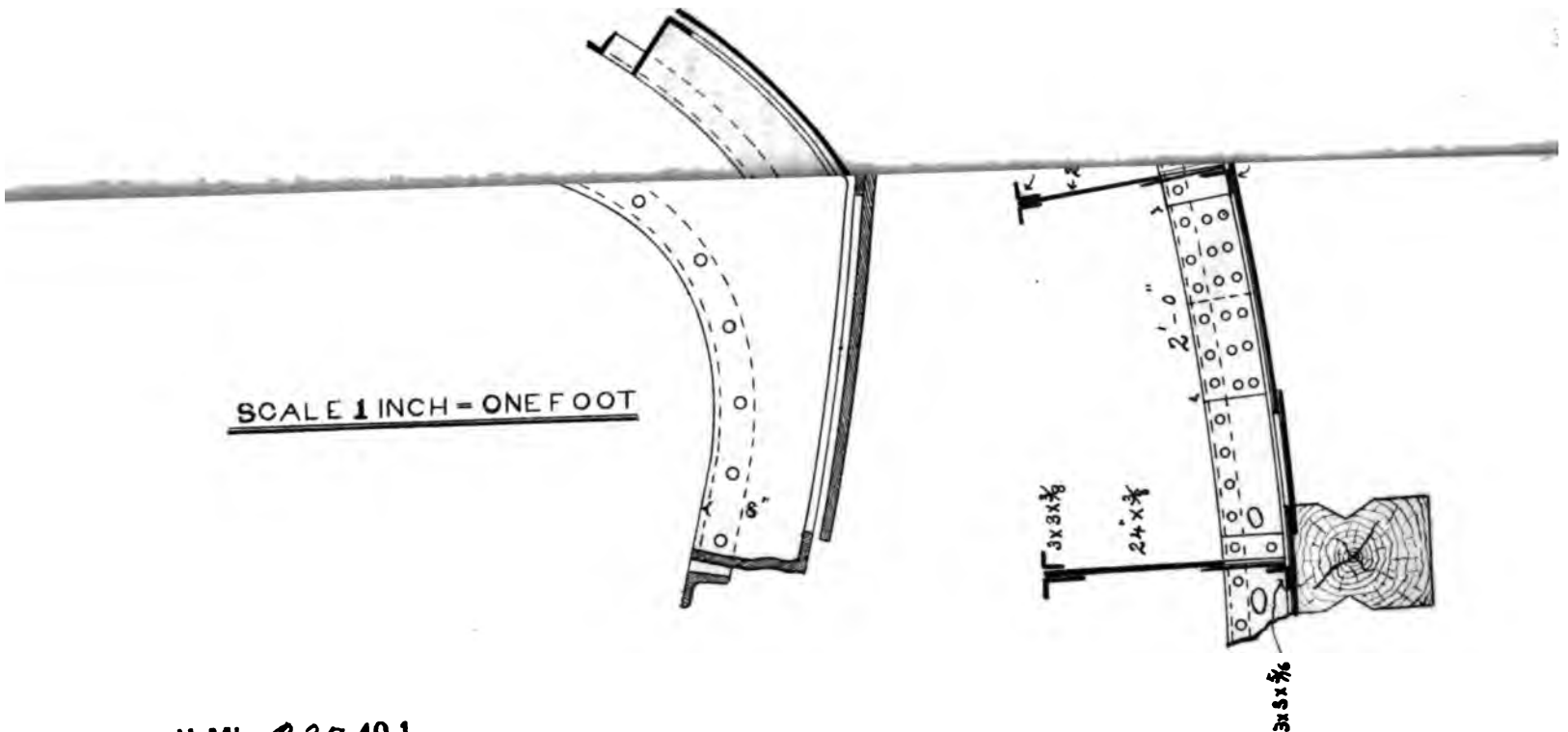

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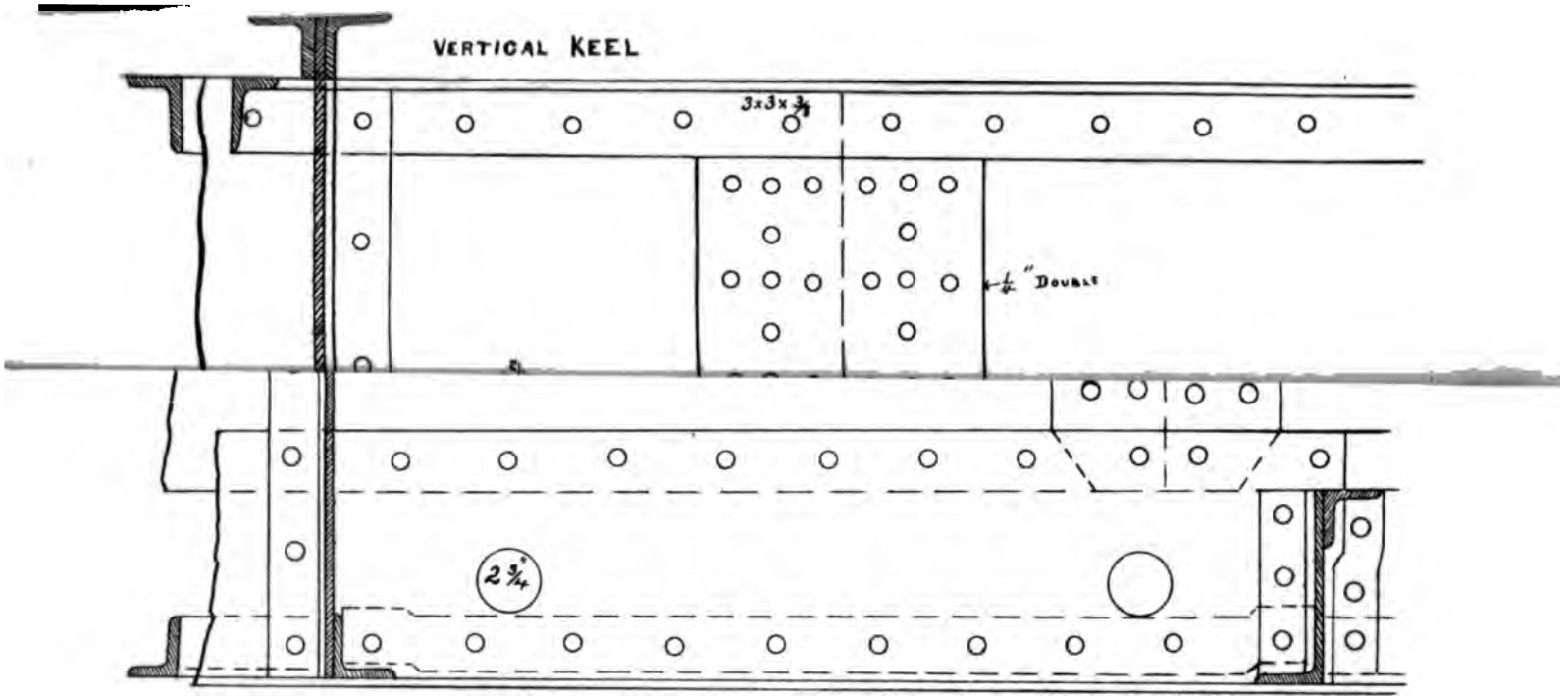

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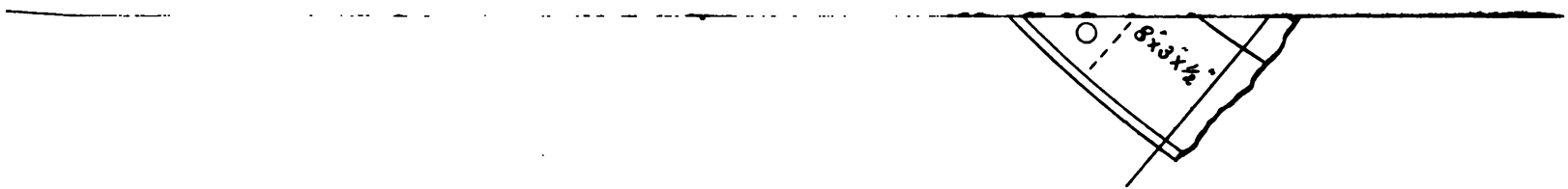
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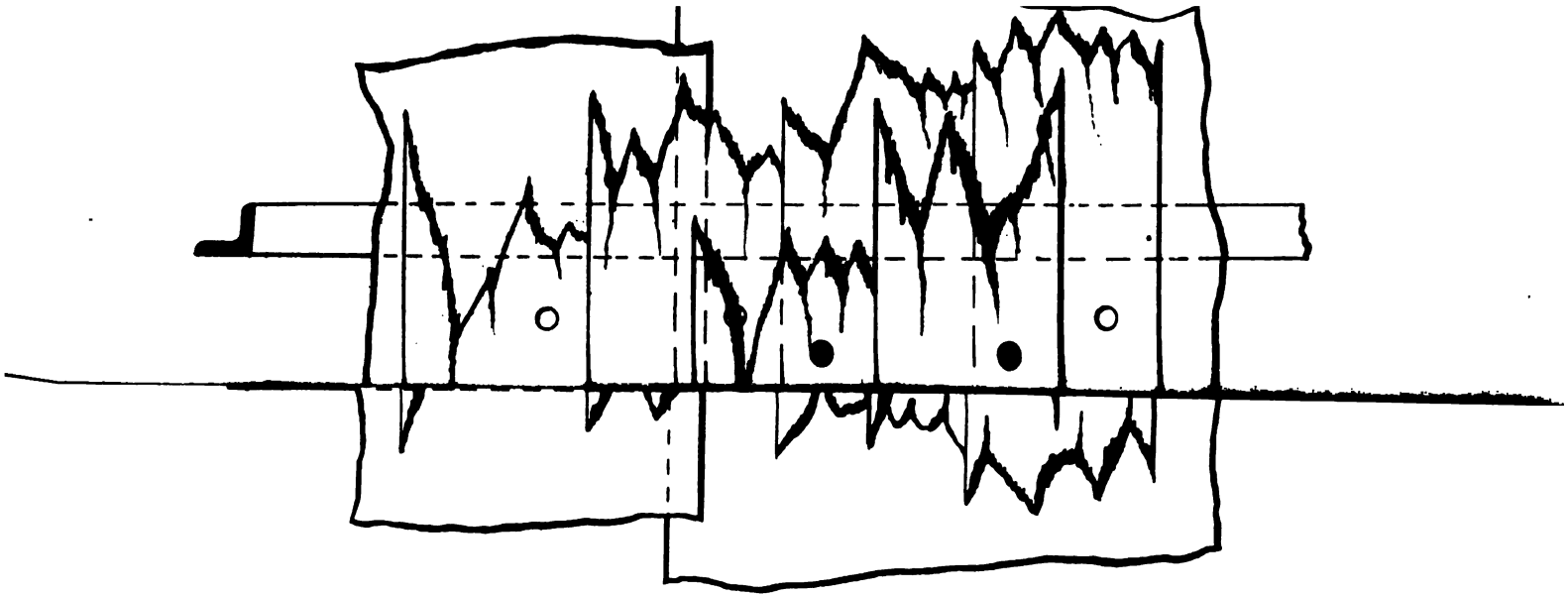

CALLIOPE.

FASTENING OF PLANK.

SCALE, 1 INCH = ONE FOOT.

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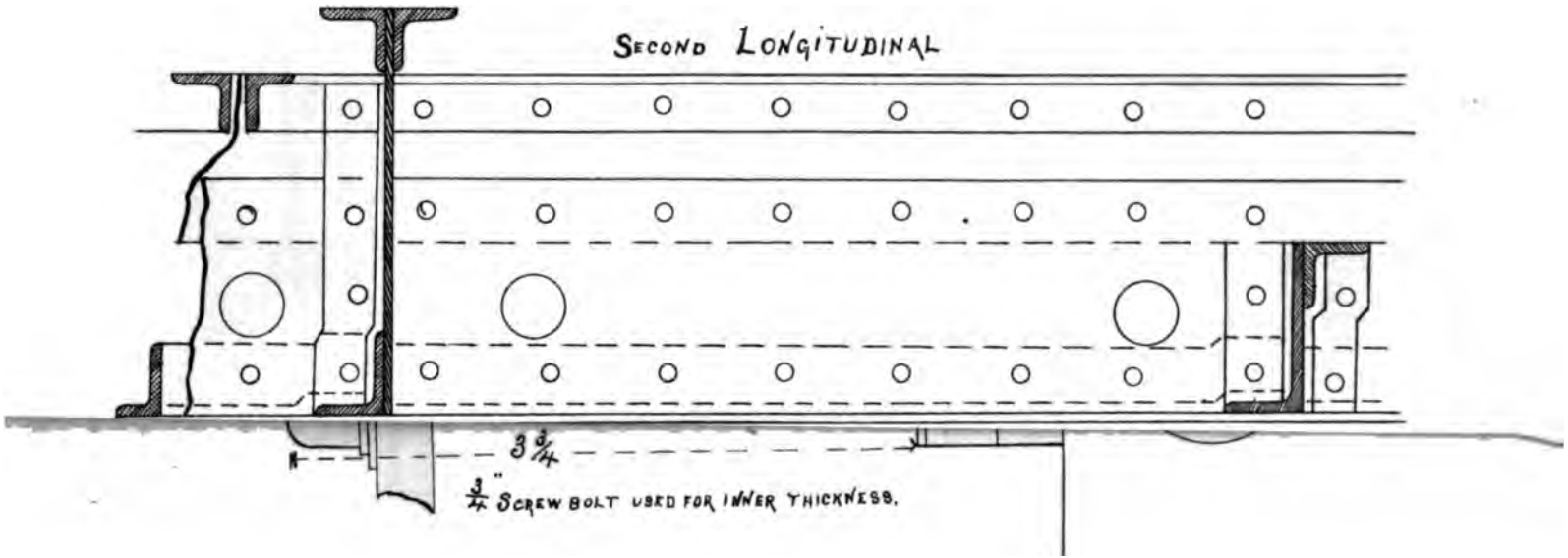

CALLIOPE

SCALE, 1½ INCH = ONE FOOT.

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feet 5 inches; her estimated speed is 16 knots, and she carries a complement of 450 men. She is sheathed with two thicknesses of wood, and, at the time of my visit, was being metalled. The armament consists of four 18-ton guns, B. L. R., disposed in four barbette towers. Two of the towers are placed on the center line of the ship forward and aft; the other two overhang the ship's sides, which are tumbled home and rounded into the deck to accommodate the fire. There are also six 6-inch guns, unprotected on the main deck. To avoid all interference with the fire of the forward barbette, an unusual and inconvenient stowage of anchors has been adopted; they are secured in pockets recessed in the side. The barbettes are round and are protected by 8-inch compound plates placed vertically. A belt of water-line armor, 8 feet in width and 10 inches in thickness, composed of steel-faced plates, is carried along in the wake of the boilers and engines. At its ends there are, athwartships, bulkheads 9 inches thick. The conning tower is of 10-inch armor; and the armored deck, which extends forward and aft, connecting with the stern-post and the ram, is 3 inches on the flat and 4 inches on the slope. The sloping sides descend 4 feet 9 inches under water. The crown is composed of three thicknesses of 1-inch steel plates fastened with 1¼ rivets; and the sides of a 1-inch plate, having a 3-inch plate above it. The thick plate is secured with tap bolts from the under side. Under this deck is the steering gear, which is further protected by being deeply submerged.

The engines are placed amidships, with boilers forward and aft of them. About one-half of the machinery was in the vessel; the remainder was unfortunately lost at sea in coming from the makers, Messrs. Maudslay, of London. It will be complete in January, and the steam trials of the ship are expected to take place early in 1885.

A longitudinal center bulkhead extends through the middle of the ship, making two engine-rooms and four fire-rooms. There are four boilers in the after boiler-rooms on either side, fired from the wings; and six boilers forward fired from the forward ends. She is brig-rigged and spreads a limited amount of sail.

THE CALLIOPE.

The Calliope, a steel and iron corvette, sheathed with wood, was also visited in this yard. This vessel was laid down in October, 1881; launched in June, 1884; and will be completed in 1885. She is of 2,770 tons displacement; and the engines, by Rennie, are to indicate 3,000 horse-power with natural draft. Four 6-inch B. L. R. are carried on sponsons forward and aft, and twelve 5-inch B. L. R. on the broadsides. There are four Nordenfeldt guns, two on the bridge and two on the bow; also two Gardner guns, one 9-pounder and one 7-pounder. The broadside guns are on Vavasseur carriages and train through an angle of 120 degrees. The estimated speed is 13¼ knots.

I have considered it necessary to give in detail the dimensions and structural arrangements of this ship, as she is one of the latest sheathed ships in the British navy; and vessels of her type, with a reduced draught of water, are suitable for many requirements of the United States Navy.

The length between perpendiculars is 235 feet; extreme breadth, 44 feet 6 inches; draught forward, 17 feet 5 inches; draught aft, 19 feet 11 inches. She differs from her sisters, the Canada and Cordelia, in being 10 feet longer. The freeboard is 8 feet 10 inches. The area of midship section is 663 square feet.

The framing is partly transverse and partly longitudinal. Some p tions of each system are continuous and others intercostal. The tra verse frames are 3 feet 6 inches apart and are of two sorts.

(1) The principal frames, which are composed of a frame angle 3″ 3″ by ⅜″ and a double reverse bar 2½″ by 2½″ by ½″ continuous across t keel, the two being connected by ⅝″ floor-plates, which amidships gi way to the longitudinals. The floor-plates are lightened by large hol and connect to the longitudinals by clips 2½″ by 2½″ by $\frac{5}{16}$″. At the tu of the bilge this arrangement scarphs to frames composed of an out angle 8″ by 3½″ by ⅜″ and a reverse bar 2½″ by 2½″ by $\frac{5}{16}$″ (see Figure The 8-inch frame extends up to the lower or armor deck, and is attach to it as shown in the sketch.

(2) The intermediate frames, which are composed of a frame ang 8″ by 3″ by ½″ and a reverse bar 2½″ by 2½″ by $\frac{5}{16}$″, both of which are co tinuous across the keel, from the steel deck on one side to the sa height on the other, cutting away the lower portion of all the longitu nals and attaching to the steel deck as shown by sketch.

Before station 20 and abaft 49, frame angles 6″ by 3″ by ⅜″ are e ployed, extending right up to the rail.

In the wake of the steel deck all of the frames are cut off. Above Z steels are worked, 3 feet 6 inches apart, extending up to the rail a connected to the deck as shown.

The longitudinals are as follows:

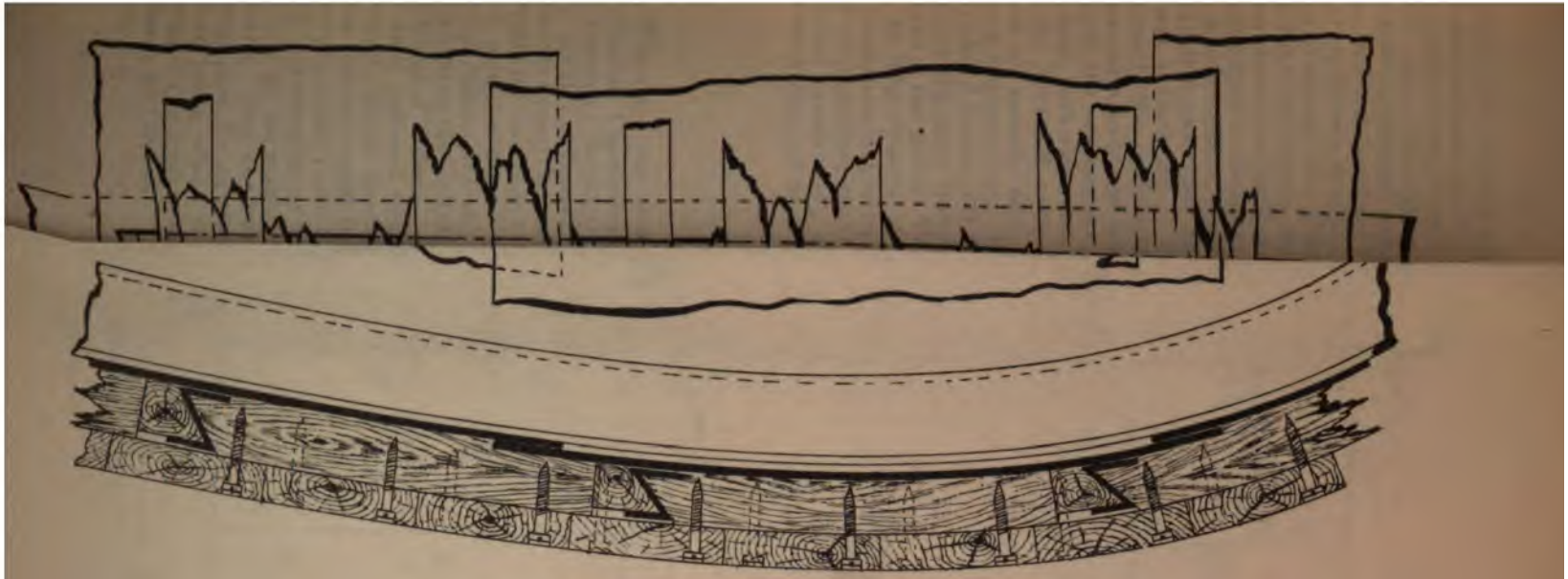
The center keelson consists of a vertical steel plate 24″ by ⅜″, wi three-eighths inch intercostals fitted at the bottom between the 8-in frames and riveted to the continuous plate; a flat keel-plate 3 fee inches wide by one-half inch thick, is connected by 3″ by 3″ by ⅜″ ang to the vertical plate. The upper flange of these angles is cut away allow the frames to pass through. On the upper edge of the verti plate there is a double 3″ by 3″ by ⅜″. The plate is worked in 21-f lengths, connected by double butt-straps one-fourth inch thick and r eted with three-fourths inch rivets. The intercostal plates have wat courses 2¾ inches in diameter.

The first longitudinal on either side of the keel is of the same style construction as the keel itself. This is illustrated and sizes given in t figures. In every frame space the longitudinal is lightened by a h 18″ by 8″, except where butts occur. The second longitudinal is p together in like manner, and the sizes of the plates and angles are giv in a sketch. A third longitudinal, 11 inches deep, is fitted as an int costal, with a double 2½″ by 2½″ by $\frac{5}{16}$″, running on the inside of t frames, and clips to the skin 3″ by 3″ by ⅜″. Where the longitudin pass through the water-tight bulkheads, angles 3″ by 3″ by ⅜″ a fitted as shown in the sketches, and calked.

The first longitudinal extends from station 4 to the stuffing-box bu head. A longitudinal coal-bunker bulkhead extends from station 20 station 49. It connects above to the steel deck and below to the int costals, which clip to the skin by 3″ by 3″ by ⅜″ angles.

The steel protective deck, to which I have alluded, is built in t thicknesses of three-fourths-inch steel. It extends from station 20 station 49, and rests upon longitudinal girders. Each girder consi of a vertical plate 3 feet 9 inches by three-eighths inch, with doul angles, 3″ by 3″ by ⅜″, on its upper edge, and is connected to the de by a 3½″ by 3½″ by ½″. The ends of the girders are attached to t athwartships bulkheads.

The bottom plating is of the usual construction, with inside and o *side strakes*; the greater part is of five-sixteenths-inch steel. Il



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RUSSIAN SYSTEM OF SHEATHING.

SCALE ONE INCH = ONE FOOT.

with which the ship was at first fitted. The consequences are that the torpedoes are discharged in the wake of a sliding gun-metal guard, by which they are shielded from the pressure of the water until quite clear of the ship, and the boilers, the removal of which almost involved the destruction of the midships portion of the ship, have been superseded by those of common type. New bunkers were constructed to suit the changes in the fire-room. The present coal capacity is 113 tons. The system of drainage was completely changed, and an arrangement of electric incandescent lamps and search-lights was made by the Messrs. Siemens. The Polyphemus made a full-power trial of her machinery on the measured mile on May 21, 1885, with very satisfactory results. A speed of 17.847 knots was realized, and the indicated horse-power was 5,521.

The steel dispatch vessel Mercury, whose great speed attracted much attention some time ago, was here ready for commission. The Dreadnaught was about to relieve the Inflexible as flagship of the Mediterranean squadron. The Rupert, Active, Volage, Cordelia, Triumph, and Bacchante, were all ready for sea. Many older vessels were laid up or refitting. Among these the royal yacht Victoria and Albert was undergoing extensive repairs both to hull and engine, Messrs. John Penn & Son supplying new cylinders, and the dock-yard furnishing new boilers. Several Indian troop-ships were also receiving a thorough overhauling.

THE HECLA.

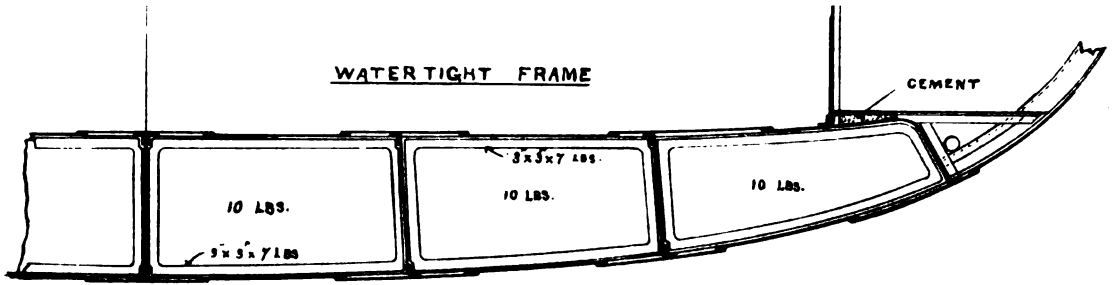
A ship which invited much attention was the torpedo depot Hecla. Originally a merchant steamer, she was purchased and fitted out by the Admiralty as a floating torpedo store and workshop. She is 391 feet long, 38 feet 9 inches beam, and has a displacement of 6,400 tons, and engines of 1,760 I. H. P. She carries five 64-pounder M. L. R., and one 40-pounder B. L. R., also a number of torpedo-boats for distribution among the fleet in time of war, a supply of torpedo nettings and all the materials and appliances to ward off or inflict torpedo attack. Her men were found to be of exceptional intelligence, thoroughly schooled in the use and manufacture of all forms of explosive appliances.

On the main deck aft there is quite a large machine-shop, with lines of shafting running the light lathes, shapers, and planers required for torpedo manufacture and repair. So highly is this vessel thought of that the building of a new Hecla, or, possibly, the conversion of some of the obsolete iron-clads, like the Warrior, into torpedo transports is spoken of as part of the naval programme of the future.

The Active, which was seen here, an iron corvette sheathed with wood, seemed of a type which, with a reduction of draught, is suited to the needs of the United States. She is of 3,080 tons and 4,010 I. H. P.; The length is 270 feet; breadth, extreme, 42 feet, and draught of water, 21 feet 4 inches. She is ship-rigged and has full sail power. The speed under steam is about 15 knots, and the armament is eighteen 64-pounders M. L. R. guns.

TORPEDO-BOAT DEPOT.

At Haslar, on the opposite side of the harbor, the Admiralty have fitted up a large property for housing and storing torpedo-boats and light gunboats. The vessels are drawn out of the water on a railway and deposited on a traveling platform, which runs on rails in a wide trench. On both sides extend substantial sheds, in which the boats are



MERSEY
MIDSHIP SECTION.

ONE FOURTH OF ONE INCH = ONE FOOT.

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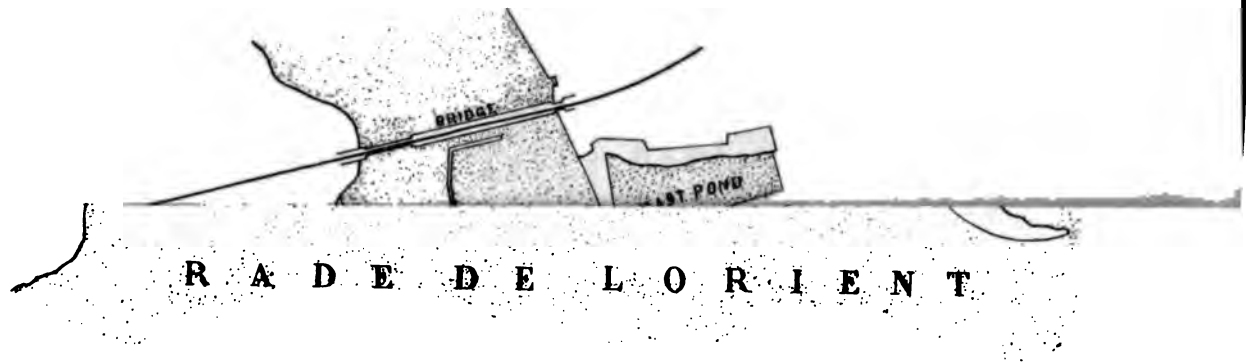

PLAN OF LORIENT.

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rthed side by side. Each berth is fitted with rails to facilitate the ansfer of the boat from the truck.

The platform is operated rapidly by steam power, and the same ma-inery answers for drawing the boat from the water. I was informed at as many as fifteen boats could be housed or launched in an ordi-ary working day. Many twin-screw light-draught gunboats were ored here to prevent deterioration, and afford facilities for painting nd repair.

CHATHAM.

(The armorclads *Rodney* and *Hero*, partially protected cruisers *Mersey*, *Severn*, *Arethusa*, *Leander*, and *Phaeton*.)

Her Majesty's dock-yard at Chatham is but little inferior to Ports-outh, having also received an extension during the last ten or fifteen ears; the improvements being still incomplete. More building opera-ions were going on here than at Portsmouth. The Rodney, a ship of he Collingwood type, since launched, was progressing rapidly. In iew of the details already given, regarding similar vessels, a special escription is omitted. The Rodney is on the same lines as the Howe, aving 9,600 tons displacement and 7,500 I. H. P. A speed of 16 knots anticipated. The Rodney was commenced on the 6th of February, 882, and was launched on October 8, 1884, up to which time the hull presents an expenditure of £440,000. She is the second ship of the ass; the Collingwood, launched at Pembroke in November, 1882, was he first.

Reference has now been made to all of the Admiral class building in he several dock-yards: the Anson and Howe, at Pembroke; the Col-ngwood and Camperdown, at Portsmouth; and the Rodney, now com-leting at Chatham. The Benbow, of 10,000 tons displacement, is uilding by contract at the Thames Iron Works at Milwall. There are, herefore, six of these powerful vessels. The Benbow will carry the eaviest armament of any ship in the navy, having two 110-ton guns; er broadside guns are ten 5-inch B. L. R.

These ships are rated first-class armor-clads; but if the line be drawn t 10,000 tons it is necessary to rule out the Collingwood, Rodney, and Howe. None of them will have sails; there will be one mast, to be used or signaling and machine guns.

The Hero, a new Conqueror, was building in one of the docks. The Conqueror herself was approaching completion. She has a displace-ment of 6,200 tons and twin-screw engines of 4,600 I. H. P. She car-ies two 43-ton B. L. R. guns in a single turret. Her length is 270 feet; readth, 58 feet; draught forward, 22 feet; draught aft, 24 feet. The hickest armor on the water-line is 12-inch. That on the turret is also 2-inch; all steel faced. Over the citadel there is a 1¾-inch steel deck, nd on the lower deck 2½-inch plating extends forward and aft.

The guns of the Conqueror do not possess an all-around fire. They re masked by the superstructure which contains the quarters. The urret has an arc of fire of 280 degrees.

The Calypso was visited here, being similar to the Calliope, whose imensions and arrangements have already been described.

The Mersey and Severn, building, were precisely like the Thames onstructing at Pembroke.

The Warspite, a duplicate of the Imperieuse, was in one of the basins ompleting. The Leander, Phaeton, and Arethusa, built at Napier's

one 90-millimeter aft, and two 37-millimeter Hotchkiss guns, one of the latter on the signal mast and the other in the conning tower. The Fusee has twin-screw engines of 1,500 indicated horse-power, collectively, and is expected to make 14 knots. She carries 46 tons of coal, and has a complement of 70 men. The cost of hull and outfit is $216,000; engines, $105,000; armament and stores, $19,500. There is no rig except a signal pole. She is rated a second-class gunboat. The first class is of 1,600 tons displacement and carries 200 tons of coal.

BREST.

(Iron-clads *Neptune, Amiral Baudin, Devastation;* the unarmored cruiser *Sfax*, &c.)

The dock-yard at Brest is situated at the mouth of a small inlet, on the north side of the Rade de Brest. On the east side of the town is the commercial harbor, protected by a breakwater; to the west the arsenal, which occupies both sides of the inlet just mentioned, up which it extends for a distance of a mile or more. The situation is a peculiar one. The surrounding country being high, the dock-yard is narrow and very long, and the shops and stores are placed at different elevations on the precipitous sides. Although several floating bridges are provided, the long and narrow character of the yard makes some portions of it rather inaccessible. The area is stated at 145 acres. The dry-docks and some of the smaller building slips are on the western side, on which are also the machine shops, situated on an elevated terrace, from which a large stone arch has been sprung out to the water's edge, and fitted with a powerful crane for handling the machinery of vessels.

The larger building slips and the shops containing the ship tools are well up the inlet on the east side. Great additions had recently been made to this department, and the new and extensive buildings were being stocked with superior tools. A general plan of the yard is presented, but it does not show some of the latest improvements.

THE NEPTUNE.

The Neptune, a full-rigged, twin-screw barbette ship, was completely plated, and was under one of the improvised ship-houses already spoken of. This ship, which will be launched during the present year, is built of iron and steel, and has a displacement of 10,375 tons on a mean draught of 25 feet 3 inches. Her water-line armor, which was being taken off in templates at the time, will be of compound plates of 1[illegible] inches maximum thickness. There will be three barbettes, each containing one 40-ton gun, protected by 15¾-inch compound plates. She will also carry eighteen 5½-inch guns. The estimated speed is 16 knots. The coal capacity is 800 tons, and at 10 knots' speed she is expected to steam 3,500 knots.

THE AMIRAL BAUDIN.

The Amiral Baudin, launched June 5, 1883, was approaching completion. This twin-screw barbette ship is a very powerful vessel of nearly the dimensions of the Formidable, building at Lorient, having a displacement of 11,380 tons on 25 feet 9 inches draught, and the same armor, armament, and power.

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DEVASTATION.

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THE DEVASTATION.

The Devastation was at the quay, ready for sea, about to depart for China. This fine casemated barbette ship was commenced in 1876 and launched in August, 1879. In accordance with the French practice of that period, the frames are of steel and the plating of iron. The displacement on a mean load draught of 24 feet is 9,639 tons. The water-line armor is 15-inch; that on the casemate is 9½-inch. She carries four 32-centimeter guns in the casemate; two 27-centimeter guns in half turrets and six 14-centimeter guns. The complement is 600 men. Her twin-screw engines develop over 6,000 indicated horse-power, and give a speed of nearly 15 knots. The coal capacity is 600 tons. She is ship-rigged, and has a large spread of canvas.

The Tempete and Tonnerre, coast-defense vessels of the turreted type, were also visited at this yard.

THE SFAX.

The Sfax, an unarmored cruiser, launched May 26, 1884, was fitting out for service on the coast of Tunis. As long ago as 1872 one of the chief constructors designed and suggested a corvette of this class as more economical and quite as efficient as the frigates Duquesne and Tourville, which were imitations of the Inconstant and Shah, of the English navy, these latter again owing their construction to the Wampanoag and class of the United States. Bertin's ideas were followed in the Sfax, which is admitted to be of far greater military value than the Duquesne, although of 1,280 tons less displacement. The hull of the Sfax is built entirely of steel, wood sheathed and coppered. She has a steel deck, 1.57 inches thick, over the machinery, boilers, magazines, &c. Between this and the gun-deck the space is divided into water-tight cells by means of seven longitudinals and sixteen athwartship bulk-heads, the spaces serving as coffer-dams, coal-bunkers, and store-rooms.

The principal dimensions of the ship are as follows:

Length between perpendiculars	feet..	289¾
Extreme breadth	do...	49 9/16
Depth in hold to protective deck	do...	20¾
Mean draught	do...	22 11/24
Trim	do...	5 7/12
Area of immersed midship section	square feet..	820
Displacement	tons..	4,428

The armament consists of guns of the 1881 model, of which six 16-centimeters are carried on the spar-deck, four in half turrets, and two in recessed bow-ports nearly abreast of the foremast. On the gun-deck are ten 14-centimeter guns. The lighter armament is composed of eight machine guns.

The two engines are separated by a longitudinal water-tight bulk-head. The propellers have a diameter of 17 feet 7 inches, and a pitch of 20 feet 10 inches. With 90 revolutions, under forced draft, a speed of 16¾ knots and 7,500 indicated horse-power is anticipated, while under natural draft a speed of 15 knots with 5,000 horse-power is expected. The boilers are cylindrical, six in number, each having two furnaces, with a total grate surface of 537.3 square feet, and a heating surface of 18,807 square feet. The ordinary coal supply is 536 tons, which, however, can be increased to 800 tons, sufficient to take the vessel 6,200 miles at a speed of 10 knots.

The chief component weights of the displacement are:

	Tons.
Hull, including the protective deck	2,067
Armament	246
Engines and boilers	960
Coal	536
Rigging and boats	220
Crew, provisions, &c	256
Filling of coffer-dam	123
Total	4,408

The surplus of 20 tons goes to fittings for torpedo-tubes above and below water. The Sfax is full rigged. The cost of hull was 2,075,925 francs, of which 1,075,925 was for material; and the total cost ready for sea will be about 5,000,000 francs, or $950,000.

CHERBOURG.

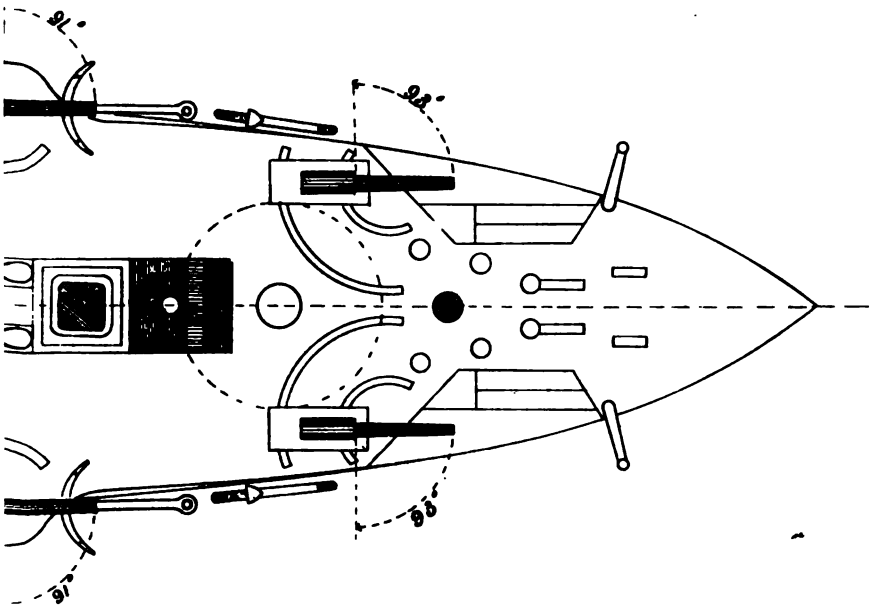
(Iron-clads *Furieux*, *Amiral Vauban*; corvette *Dubardieu*; small gunboats.)

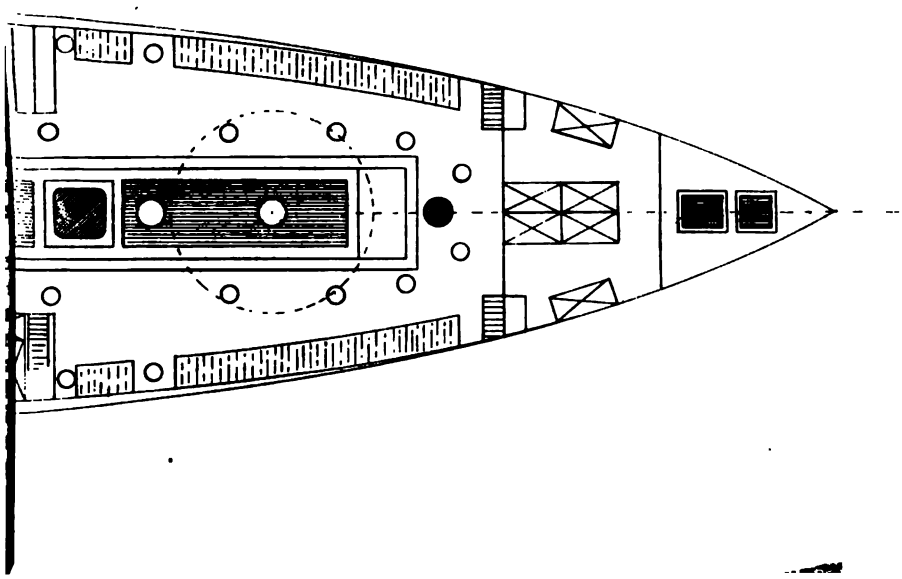
Cherbourg is the most imposing of the French dock-yards; having a number of basins and dry-docks it more nearly resembles Portsmouth or Devonport. It has an exposed situation and is entirely an artificial port. A very expensive breakwater, defended by fortifications, protects it from the sea. The land approaches are also strongly fortified. Neither the port nor the dock-yard can be said to have natural advantages. They owe their present position to Napoleon I, under whose direction many of the present works were begun and prosecuted in the face of great difficulties and at enormous cost. The area is stated at 256 acres, comprising, besides numerous buildings and shops, eleven slips, eight dry-docks, and three basins. The latter have been excavated from the solid rock and are faced and coped with massive granite. Some of the slips have permanent ship-houses.

THE FURIEUX.

In one of the dry-docks the Furieux was receiving her armor; to facilitate this work the dock had been substantially decked over at the height of the armor shelf and a railway laid for transporting the plates on a truck. This ship was launched in 1883. She is a single-screw turret ship, with a displacement of 5,605 tons on a mean draught of 23 feet 9 inches. The water-line armor is 17¾-inch compound plate, and the single turret will have 13-inch compound armor and will contain two 48-ton guns. Her engines are to develop 3,500 indicated horse-power and the speed will be about 12 knots. She will carry 290 tons of coal. The complement of men will be 163. This ship is built of iron and steel.

Several lightly framed gunboats, of 300 or 400 tons, were constructing, and a very remarkable single-screw wooden ship of 3,354 tons displacement, called the Dubardieu, which has since been launched. She is 253 feet long, 47 feet beam, and 23 feet draught. The frame and skin of the ship are of wood; the bulkheads, hatch coamings, and beams are of iron, the latter attaching to the side by an iron shelf plate and angle clips. The battery will consist of twenty-two 6-inch guns and four 7-inch, besides revolving cannon on the spar-deck. Her three-cylinder compound engines, now being made at Creusot, will indicate 3,300 hor-





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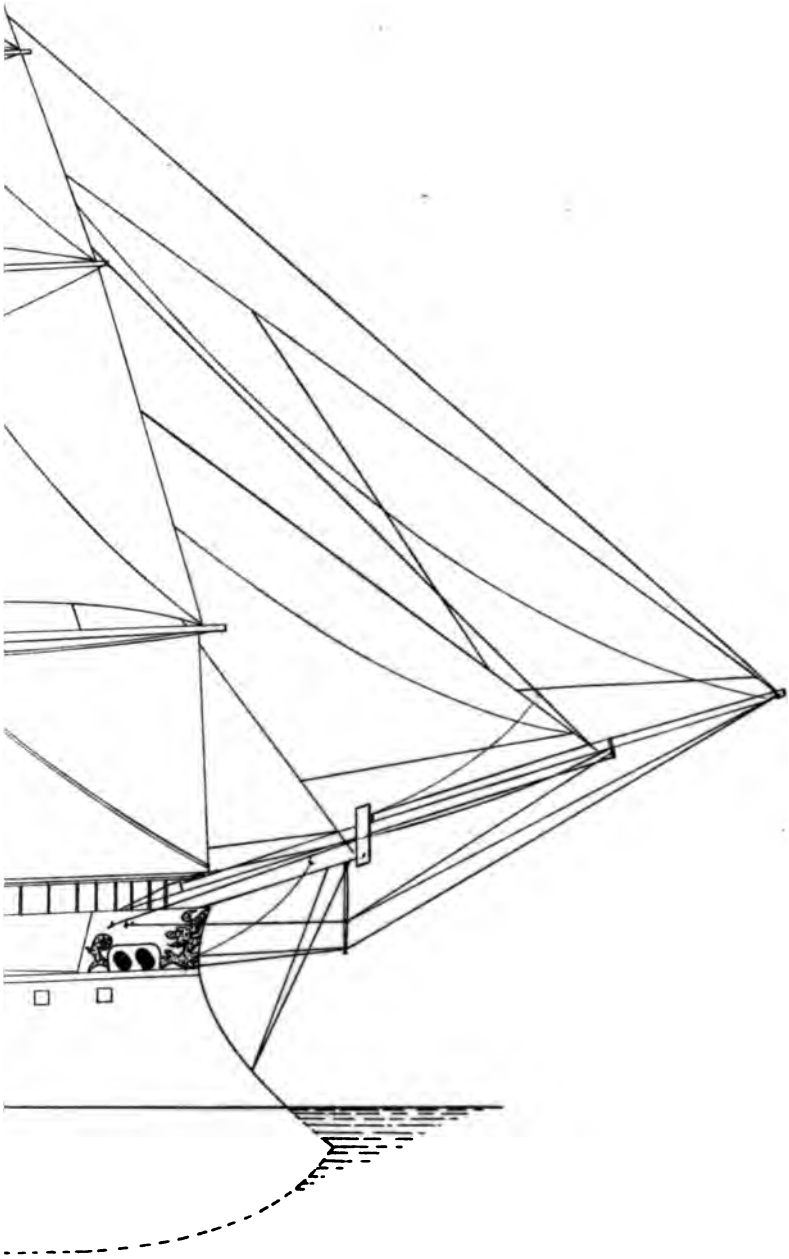

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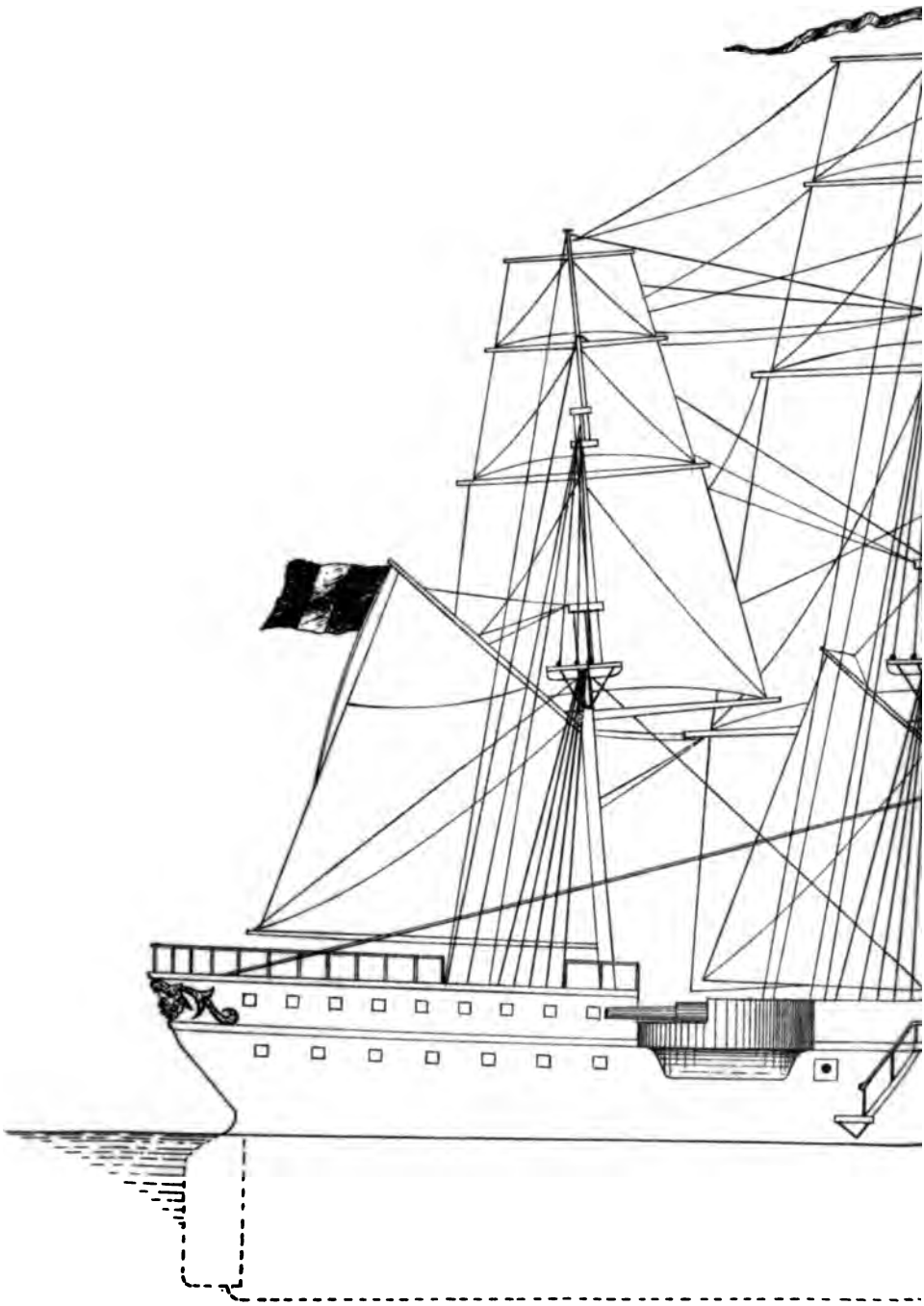

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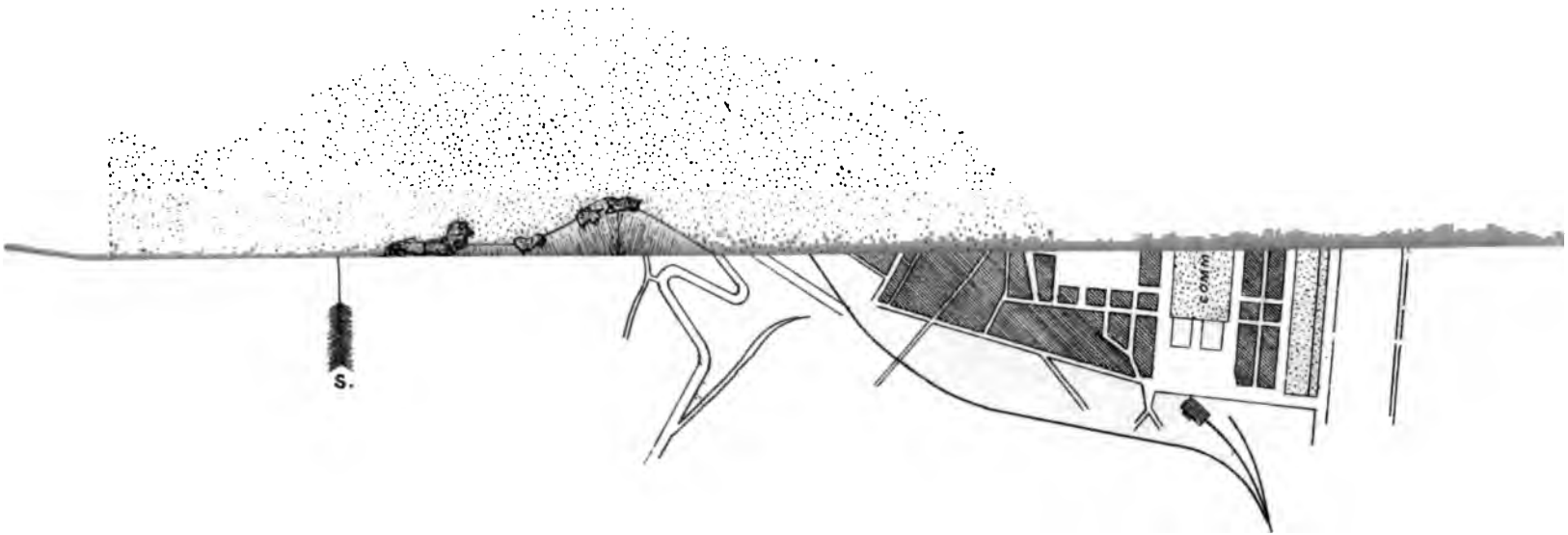

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PLAN OF CHERBOURG.

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power. The estimated speed is 14½ knots. The cost complete is given as $753,600. I considered her an admirable vessel, combining many of the advantages of iron and wood.

THE AMIRAL VAUBAN.

The Amiral Vauban, launched early in 1884, was completing in one of the docks. She is of 5,776 tons displacement, being a sister to the Duguesclin. Her mean draught is 23 feet 3 inches. The water-line is protected by 9¾-inch armor, and the barbettes by 8-inch plates. Four 15-ton guns are carried in four barbettes. The complement of men will be 450. The twin-screw engines are to develop 4,000 indicated horse-power and a speed of 14 knots. She will carry 400 tons of coal, and her rig will be that of a brig.

The Fulminant, sister to the Tonnerre, and a large flotilla of gunboats, resembling the Fusee, were at this yard. Many of these were sheathed and metaled.

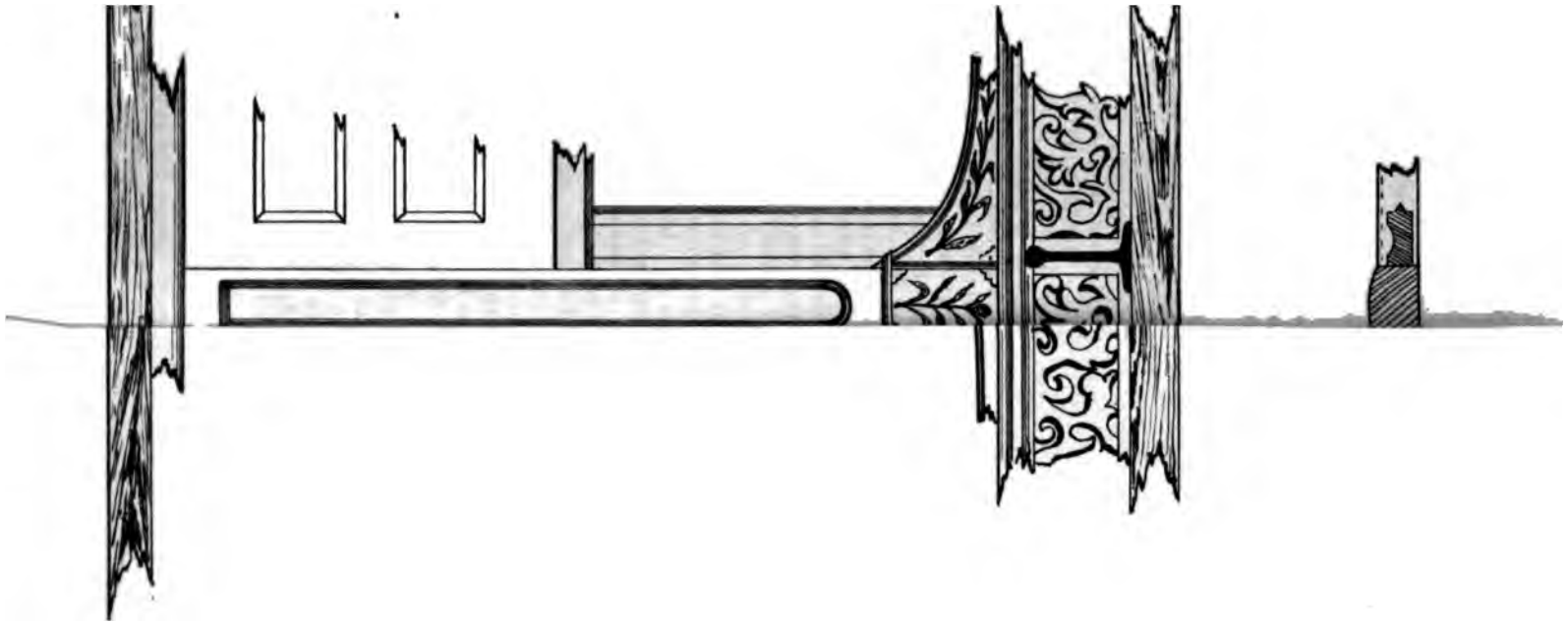
DETAILS, FITTINGS, AND EQUIPMENT OF NAVAL VESSELS.

The joiner-work and cabin fittings of a British war vessel are usually of a plain finish. Hard wood is the exception and paint is the rule; and the presence of guns in the captain's or admiral's quarters, and the frequent intrusion of the Stone pumps into the ward-rooms, manifest a willingness on the part of officers to sacrifice appearance and sometimes comfort also to the higher claims of naval efficiency. Much more elaborately finished, but still with a due regard to warlike purpose, the vessels turned out by British private yards for the Brazilian and Chilian Governments present cabin ornamentation consonant with the richer taste inherited by the South American from his Spanish ancestors. In this respect French vessels are more subdued than might be expected from conventional opinions of the national character; and the ships of Germany, Italy, China, and Japan, which I had an opportunity of inspecting, had cabins whose finish was usually quiet and sometimes cheap.

Thin iron or steel bulkheads are used in many of Her Majesty's ships as partitions in the state-rooms and cabins. In some cases a yet lighter construction is adopted and corrugated iron employed, the corrugations running vertically. When relieved by half round or other suitable pilasters and neatly painted, this produces a pleasing effect, and is both light and strong. To obviate all annoyance from sweating and rusting the iron is covered with muslin, closely laid on and well painted. In some of the new French vessels thin steel partitions are also employed, and the ventilating blinds on the doors are cut and stamped from the solid sheet.

For use in warm climates bulkheads between the state and ward rooms are sometimes made as shown in the annexed drawing. This open work permits excellent ventilation without interfering at all with the privacy of the rooms; and when the vertical slats shown are made of yellow pine and the trimmings of darker woods, the effect is quite ornamental.

In natural ventilation some of Her Majesty's vessels utilize the frame spaces; thus the bilges are often ventilated by a trunk carried along the side above the lower deck against the steel ceiling, through which numerous perforations connect the trunk with the spaces between the frames, and so with the bilge. At any convenient place the trunk is connected with the iron masts, which are most efficient ventilators. On the natural system the cabins are supplied by a trunk, near the floor, fed from several cowls placed along the top side, pipes being carried down back of the ceiling to the trunk. The foul air escapes through a register placed near the top of each state-room and passes by way the frame space up into the topside and out through small openi under the rail.



VENTILATING BULKHEAD

SCALE ¾ INCH = ONE FOOT

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But this unassisted ventilation, of course, applies only in small vessels where blowers cannot be conveniently employed. In mechanical ventilation I have found nothing superior to that now used on American war vessels; and in the matter of air ports, to which I paid special attention, I saw nothing as good as the Wilson port. Air ports on all the older ships abroad are very small; it is only on those of most recent date that the ports are of respectable dimensions. Air-port casings were found in some instances to be stamped from thin steel, and this is a considerable improvement, and one whose adoption in iron and steel vessels I should recommend.

Thin steel is largely used as ceiling, both in the space devoted to quarters and other portions of the vessel. As it is usually worked vertically and tapped to the reverse frames, it gives ready accessibility for inspection and cleaning of the skin. Of the method of working wooden ceiling in panels, to attain a like end, I have spoken in my remarks on the British Admiral Closs.

Many boats in the British navy are built wholly or in part on the diagonal system; thus, a launch will be constructed of two half-inch thicknesses of teak, fastened through and through with copper nails. Such boats are without frames, except a few floors, which are worked in to give connection across the keel. They are light and have an elastic strength, due to their peculiar construction, which cannot be obtained in any other way. When finished the fact that they are diagonally built is not perceived except on close examination. Those boats, which are built diagonally above and fore and aft on the outside below, as many are, seem to me to possess less merit, and when injured must be difficult to repair. Great numbers of boats for the royal navy are built by Mr. White, at Cowes, whose life-boats are well known. In the latter the air-tanks at the sides are built of two thin layers of mahogany with painted muslin laid between them.

Mr. White is also patentee of a large life-boat, with which some of Her Majesty's ships are fitted. It is carried thwartships on a pair of launching-ways, arranged to be inclined by a hand wheel. The boat is launched clear of the ship's side at once. It fills, of course, but immediately clears itself, as the bottom is double and provided with drain valves. As a means of saving life, a boat which can be launched instantly, without danger of being stove, has been a long-sought desideratum. These boats are diagonally built, 40 feet in length by 10 feet in breadth, and are capable of carrying one hundred and fifty men. They have been furnished to the troop-ships and other vessels. The Polyphemus has two of them. In the English dock-yards numerous collapsible boats were seen. They are patented by the Rev. E. L. Berthon, of Romsey, in Hampshire. Their construction combines buoyancy, strength, and portability. When folded they may be stowed very snugly, and on this account the smaller sizes are applicable on board torpedo-boats. The frame consists of a keel with stem and stern posts, and about three segments or planes of elm plank hinged to the heads of the stem and stern posts on either side. Canvas is stretched over these ribs, both inside and out, forming, when the arrangement is distended, a double-skinned boat, not unshapely, which can be closed up like a book. They are manufactured by the Berthon Boat Company, limited, Romsey, in various designs and sizes. Some very large ones were noticed, and they have been furnished to the French Government, with a displacement of 5 tons. When made of this size they are said to be less than half of the weight of wooden boats. The dinghies for torpedo-craft are 12 feet long, 4 feet 2 inches *wide, and 1 foot* 9 inches deep; when folded they

can be passed through a hole 13 inches long by 6 inches wide. They can be opened and launched in less than a minute and carry six or eight men. Berthon boats have been furnished to almost all European governments. They are an acquisition to exploring parties. Sir George Nares took them to the Arctic in 1874 and 1875. More recently they were carried by Leigh Smith in the Eira Relief Expedition and Gordon Pasha took them to the Soudan.

In boat davits and detaching gear nothing was noticed which calls for special mention or was any improvement upon the American system as now in use.

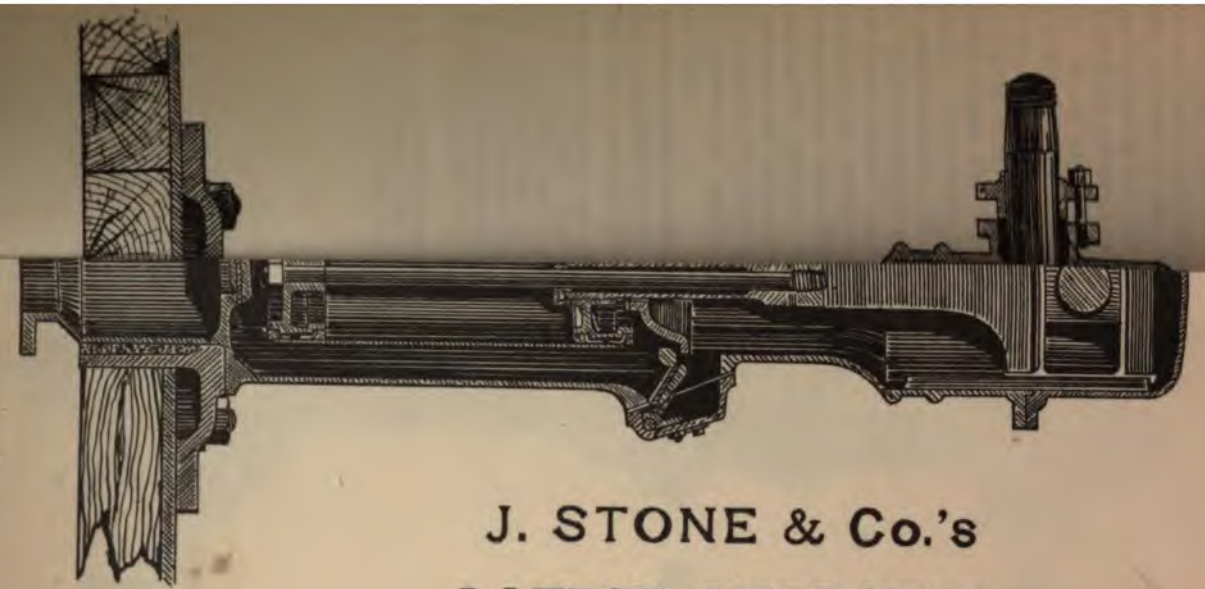
In ground tackle the Martin anchor seems to hold the preference for war ships; the Martin was more numerous than any other type, both in the British and continental navies. I have already alluded to the improved mode of working and stowing anchors as illustrated by the Riachuelo.

In the important matter of pumps and drainage no particular novelties were observed. In double-bottomed vessels the system of large drains, with screw-down and non-return valves, now being fitted on the Chicago, is common. The Stone and Dounton pumps are universal as hand pumps, and are used for the bilge and double bottom and for fire purposes. The Stone pumps have recently been the subject of improvements, whereby the number of the moving parts has been reduced and the construction simplified. Instead of three pistons, two only are now fitted, and they are without valves, the absence of which is a desideratum. The valves are all accessible without removing the pistons. The piston-rods are concentric, and one works through the other. Two pistons, as now operated, displace double the cubic inches swept by the three pistons of the Dounton. The whole contents of the barrel are discharged twice at each revolution, instead of once as in the older pump. No foot-valve is required. I transmit a sketch of this improvement. Fire mains are fitted in all foreign vessels of importance, and vary from 3 inches in the smaller ships up to 6 inches in the largest ones. They usually extend through three-fourths of the vessel's length.

The water-closets adopted by the British navy are the Stone's patent, and they attracted my attention as a superior fitting. They have double valves, and, as both valves cannot be open at once, any wash of the sea into the pan is impossible. There is also a good arrangement, by the same makers, for situations where the closet is placed below the water-line, in which case no supply-tank is required, and the water may be drawn directly from the sea.

Almost all vessels building or refitting were about to be provided with the electric light. The incandescent lamps are now of course preferred for internal lighting, although older illuminations are entirely on the arc system. The Inflexible was the first of Her Majesty's vessels to receive the electric light. She had thirty-three Brush lamps distributed between decks generally and in the fire and engine rooms. The Edison system was observed on the Indian troopers, an extensive illumination, supplied by dynamos of several patterns. In the Polyphemus two Siemens dynamos were found, driven by Brotherhood engines. This ship has two hundred and twenty Swan incandescent lamps, and a yard-arm reflector containing eight incandescent lamps of 50-candle power each. Either dynamo will produce an arc search-light of 25,000 candles. The single-wire system has been employed on this vessel, the circuit being completed by the ship.

The Colossus is fitted for both arc and incandescent lighting, being provided with three of the Brush Company's Victoria machines. One



J. STONE & Co.'s

LATEST IMPROVED

NAVY PUMP.

TORPEDO-BOATS.

The extraordinary development of this class of vessel, occurring within the past six or seven years, has been the most conspicuous feature of recent naval architecture. So essential are torpedo-boats now considered, that no European navy of note has a flotilla of less than fifty, while the stronger powers have fleets of a hundred or more. Coasts have been divided into torpedo districts, each with its complement of boats, and the crews, thoroughly organized, are kept continually exercised in the management of their vessels and drilling in the use of the arm.

The proportions of framing and thickness of plating which was at first adopted remain almost the same, any further attempt to minimize scantlings being quite impracticable. Indeed, in Germany and France a reaction may be noticed in favor of more substantial proportions, even at the cost of reduced speed. Many of the boats examined in those countries had plating double the thickness of that in the vessels of Messrs. Thornycroft and Yarrow. The establishments of these gentlemen on the Thames, near London, were visited, and a number of photographs of their later productions accompany this report.

Their practice presents many points of similarity. Some difference of external appearance is due to the fact that in Thornycroft's boats the whole width of the vessel is utilized as deck space, while Yarrow's deck rounds down at the sides, leaving only a gangway amidships. Their practice also diverges as to the machinery and the position of the propellers. The wheels of Thornycroft's boats are invariably three-bladed; the blades being of mild steel, forged to a template and then keyed to the boss, which is slotted out for their reception, as shown in the sketch. He always places the wheel forward of the rudder. Yarrow places the propeller abaft the rudder, makes it two-bladed, and forges the blades and boss from one piece of steel. He also provides the boats with two rudders, the forward one being contrived to draw up into a well. This means of steering is very efficient when the vessel is backing and the after rudder has lost its control. The boats of both builders have a turtle-back forward, which at its after end terminates in a pilot-house, where the mechanism for discharging the torpedoes is under the immediate control of the commanding officer. The turtle-back serves to house the torpedo, tubes, and gear. All recent designs have been provided with rams, these being considered a desirable means of offense in actions of torpedo-boats against each other.

A torpedo-boat requires many special fittings, most of which are characterized by much ingenuity; thus in the pilot-house the small glass windows have on the outside a wiper, worked from within, the action resembling that of an eyelid, and the purpose being the removal of spray, which gathers on the glass. The larger boats all have a special steam steering-gear; one designed by Mr. John Donaldson, of Thorny-

being considered worthy of special mention. There are often more compartments, and the bulk-heads are fitted with water-

THORNYCROFT'S
PATENT SCREW PROPELLER.

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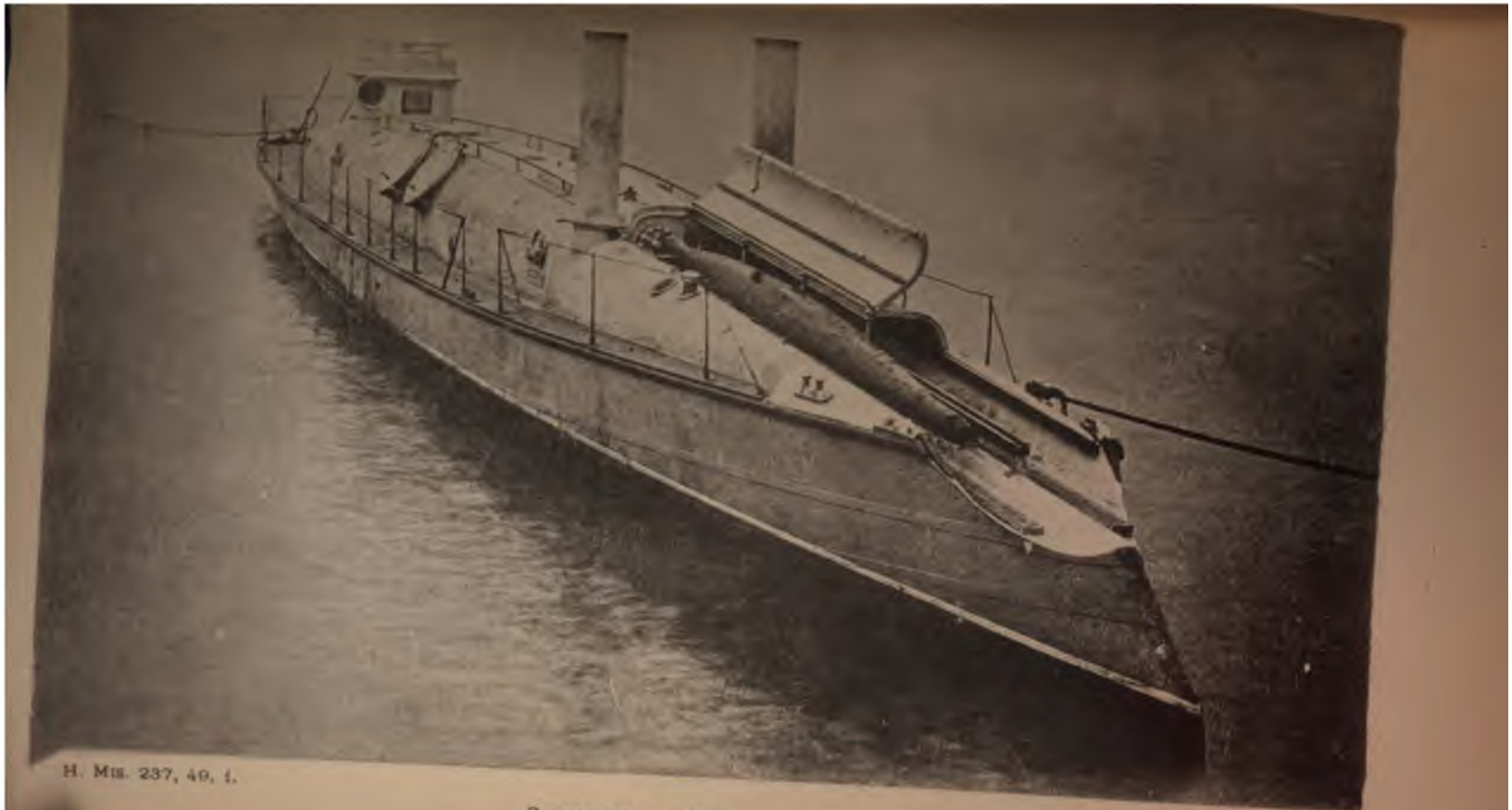

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SECOND CLASS TORPEDO BOAT.

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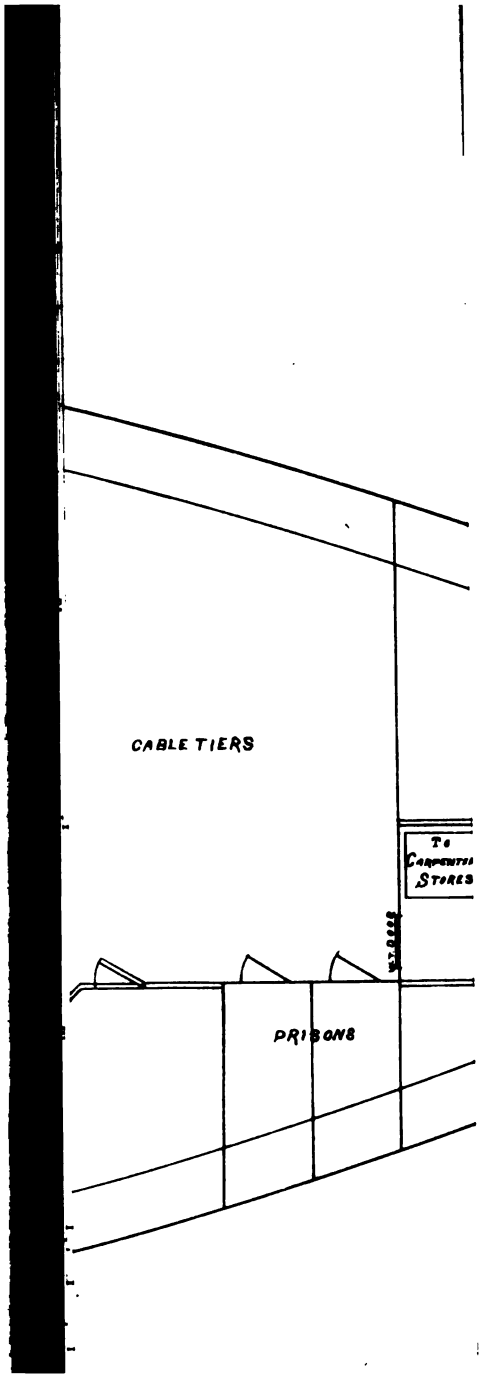
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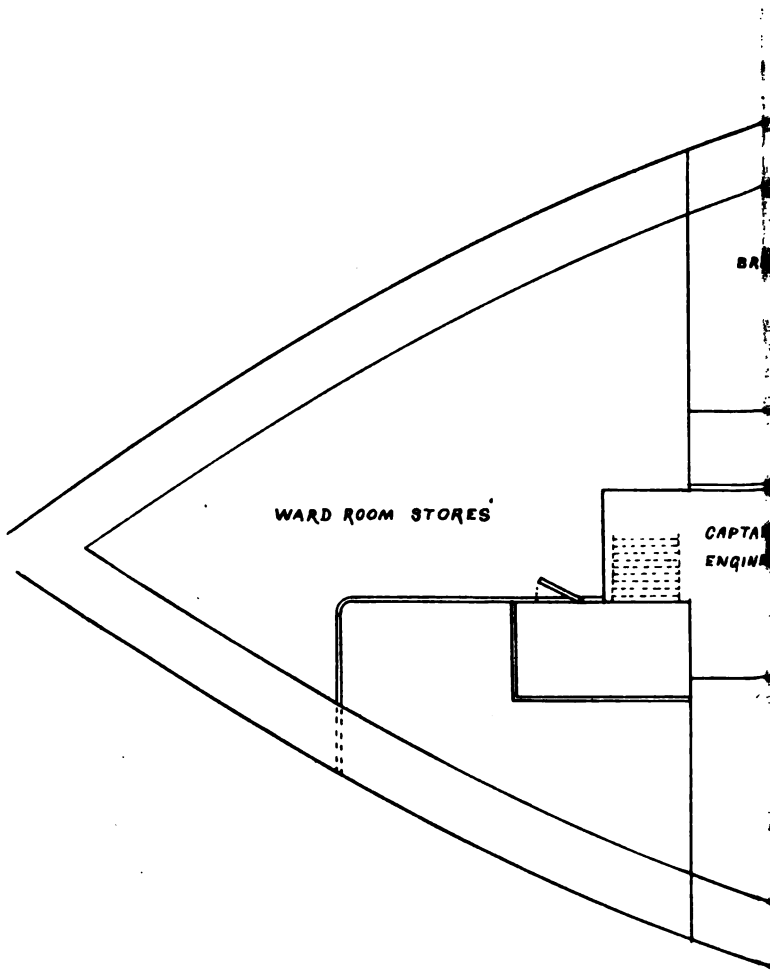

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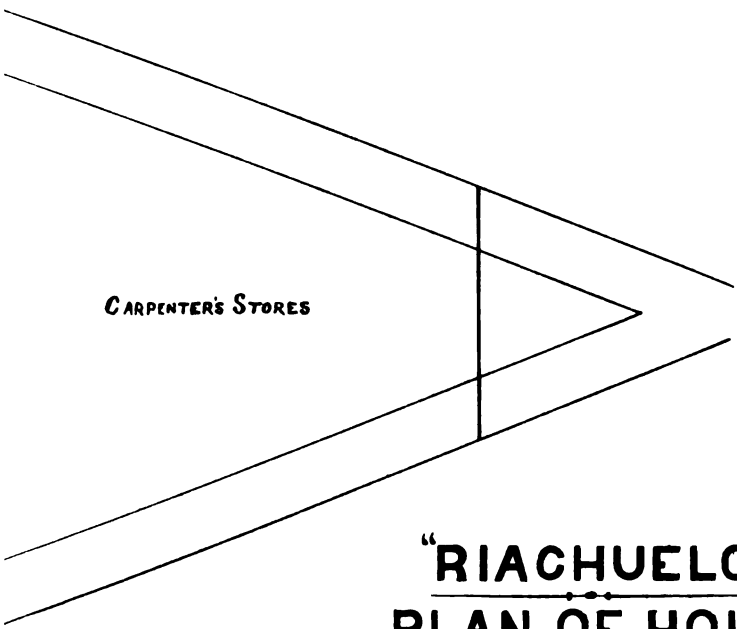

"RIACHUELO"

PLAN OF HOLD

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three-sixteenths-inch thick. Delta metal, it is claimed, can be forged l treated much like iron.

Vith regard to the torpedoes themselves, little need be said; the rific character of the weapon is widely appreciated, but its use, at st in torpedo-boats, is hazardous to the last degree. While opinions er as to the value of search-lights, the vibrations of the engines and wash of the screws are very likely to betray the direction of the at- k, and from that moment the assailants are in a position of extreme ardy.

he Whitehead is said to cost from £400 to £500. Its range may be ied from 40 to 800 yards, though at a greater distance than 600 yards not considered effective. The depth of the trajectory below the sur- e is adjustable from 5 feet to 15 feet. It attains a speed of 22 knots and kes a blow of 6½ tons. Important modifications have recently been oduced. The undulatory course in the water has been partially rected by improvements in the balance-chamber and in the vertical lders, and the charge of gun-cotton has been raised from 47 to 70 nds.

SHIP-YARD APPLIANCES AND TOOLS.

We may begin systematically with the *mold loft*. This, in many European establishments which I have visited, is disappointing; and, even in some of the larger and finer yards, fails to receive the attention which is commensurate with its great importance. The lofts are small and in a majority of cases poorly lighted. Even in Her Majesty's dock-yards those lofts which I had the privilege of inspecting were unsatisfactory.

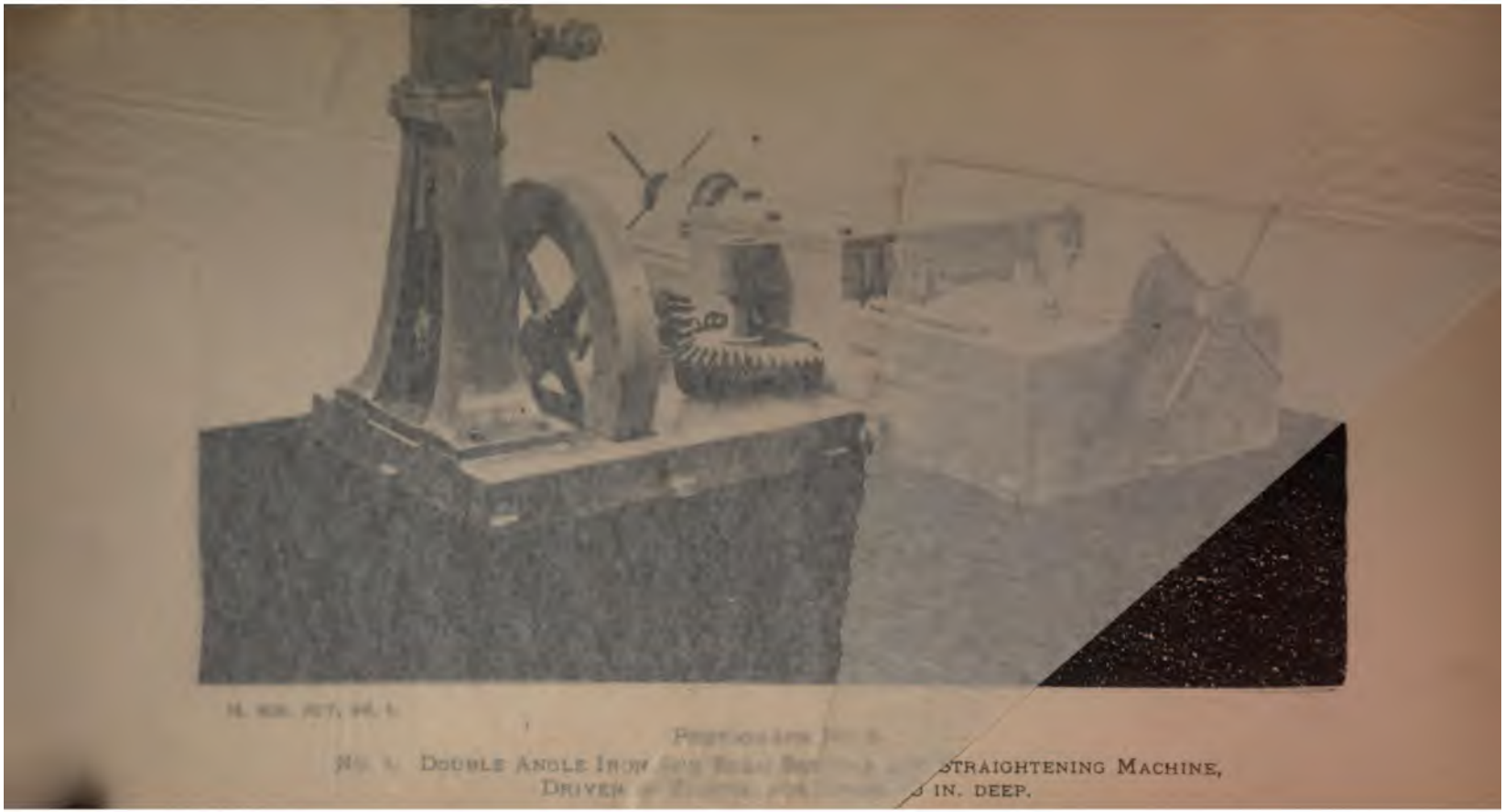
The contracted method of laying down is used almost everywhere and it possesses many advantages. In England the system of working with skeleton molds is largely pursued; in Scotland the scrieve-board is universal. In France, also, I saw this important adjunct of fairness and accuracy employed with great perfection, the strake's edges being elaborately painted in, and every frame permanently numbered with a small brass plate stamped with the proper figures and nailed to the board. Shapes are generally transferred from the body plan to the bending slab by the aid of a piece of flat iron, a quarter of an inch in thickness and about an inch and a half in breadth. This is easily brought to the proper contour by a few taps of the hammer. When the frames leave the slab, after being bent, they are tested by the scrieve-board and set cold to any required degree of exactness; a process which is calculated to insure very elegant workmanship. I would state here, however, that I have seen no sample of fine and fair iron-work abroad surpass that of certain American builders.

In bending slabs and heating furnaces I have nothing special to notice. In large yards the double-ended arrangement of bending floor is common, the angles being drawn from both extremities of a long furnace and worked on two separate slabs. The plate furnaces are always adjacent. Some floors are provided with hydraulic capstans conveniently located: and for handling a frame of heavy section, or for bending davits and stems, these are sometimes of great value. Such capstans, which adjust themselves automatically to the work to be done, using no more water than the duty requires, have a wide field of application in all concerns which are provided with hydraulic plant.

For dishing plates for keels, I elsewhere allude to the machine built by Messrs. Thompson. For turning down garboards I herewith transmit illustrations and prices of several powerful tools by Messrs. Shanks, of Johnstone, and Messrs. Craig and Donald, both eminent makers in the vicinity of Glasgow. The beds of these tools were found liable to crack when a number of hot plates were bent in rapid succession, and in the best ones the bed is arranged to be filled with water to obviate such disasters. All of the machines of this class which I have examined are operated by hand.

Plate-planing machines are usually screw planers with a beveling tool-holder, the box being reversible for planing both ways. The length is frequently 20 feet, and the clamping beam is often overhung to allow the longest plates to be planed in repeated cuts.

For the cold setting of frames and beams, the laborious table and hand screw are entirely ignored by the best yards, and machines substituted



No. 1. Double Angle Iron [illegible] Straightening Machine,
Driven [illegible] in. deep.

SHIP-YARD A

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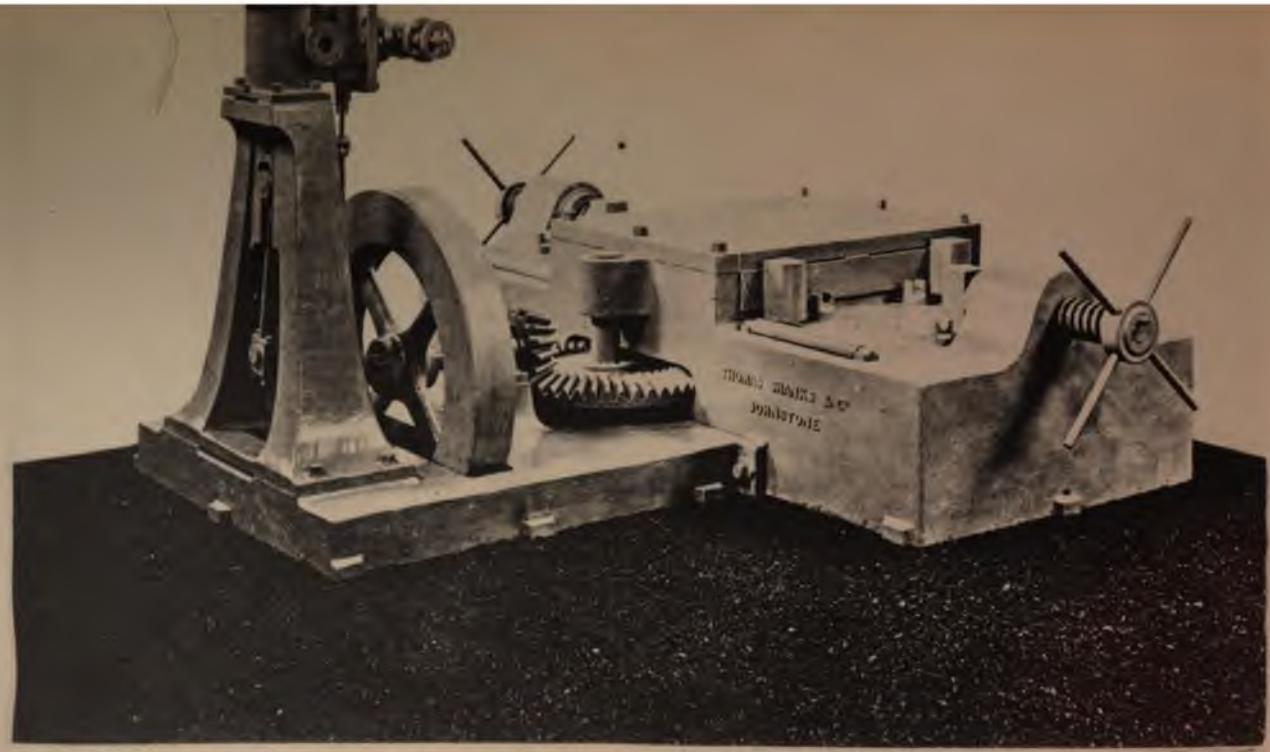

PHOTOGRAPH No 3.

No. 1. DOUBLE ANGLE IRON AND BEAM BENDING AND STRAIGHTENING MACHINE, DRIVEN BY ENGINE, FOR BEAMS 15 IN. DEEP.

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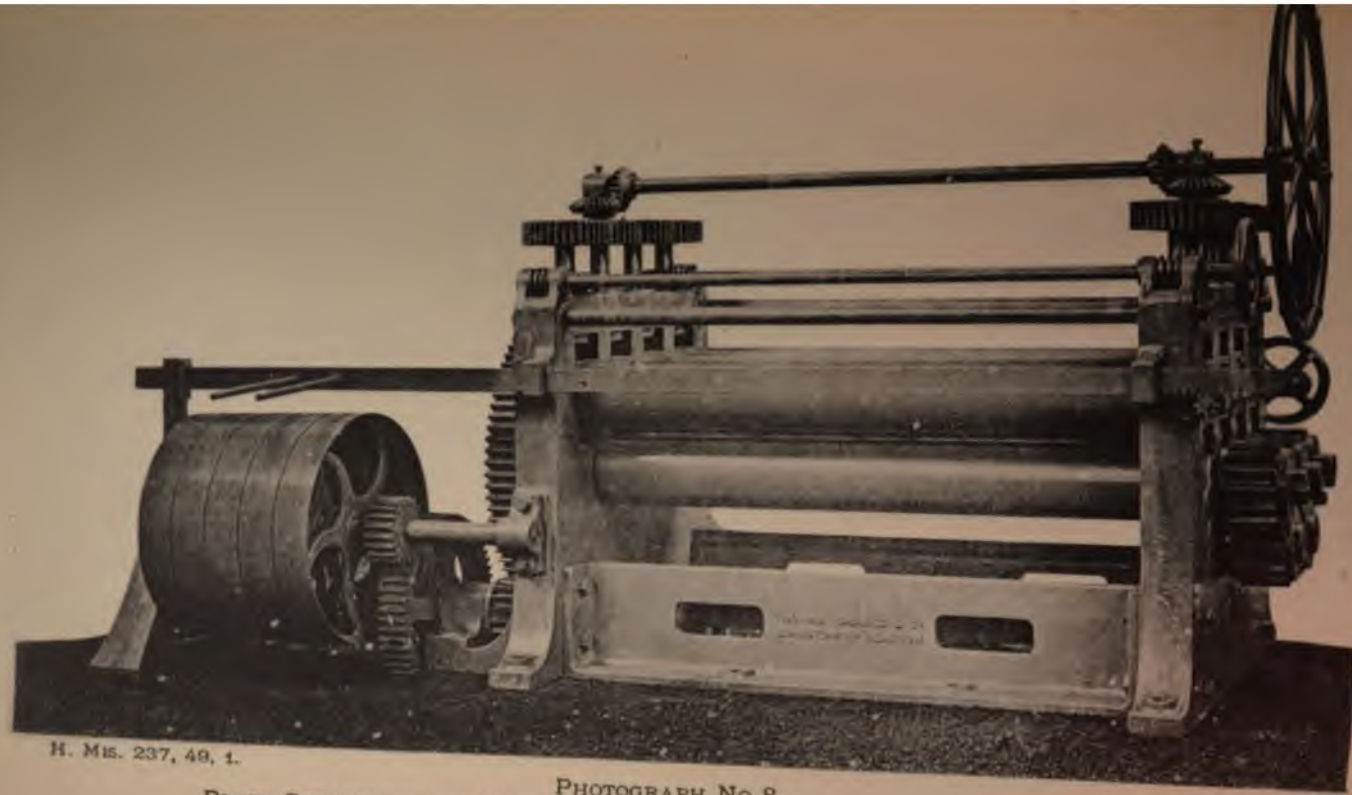

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PHOTOGRAPH No 8
PLATE STRAIGHTENING MACHINE, FOR WORKING IN 1-2 IN. THICK & 6 FT. LONG,
WITH 7 FORGED IRON ROLLERS 9 IN. DIA.
DRIVEN BY PULLEYS.

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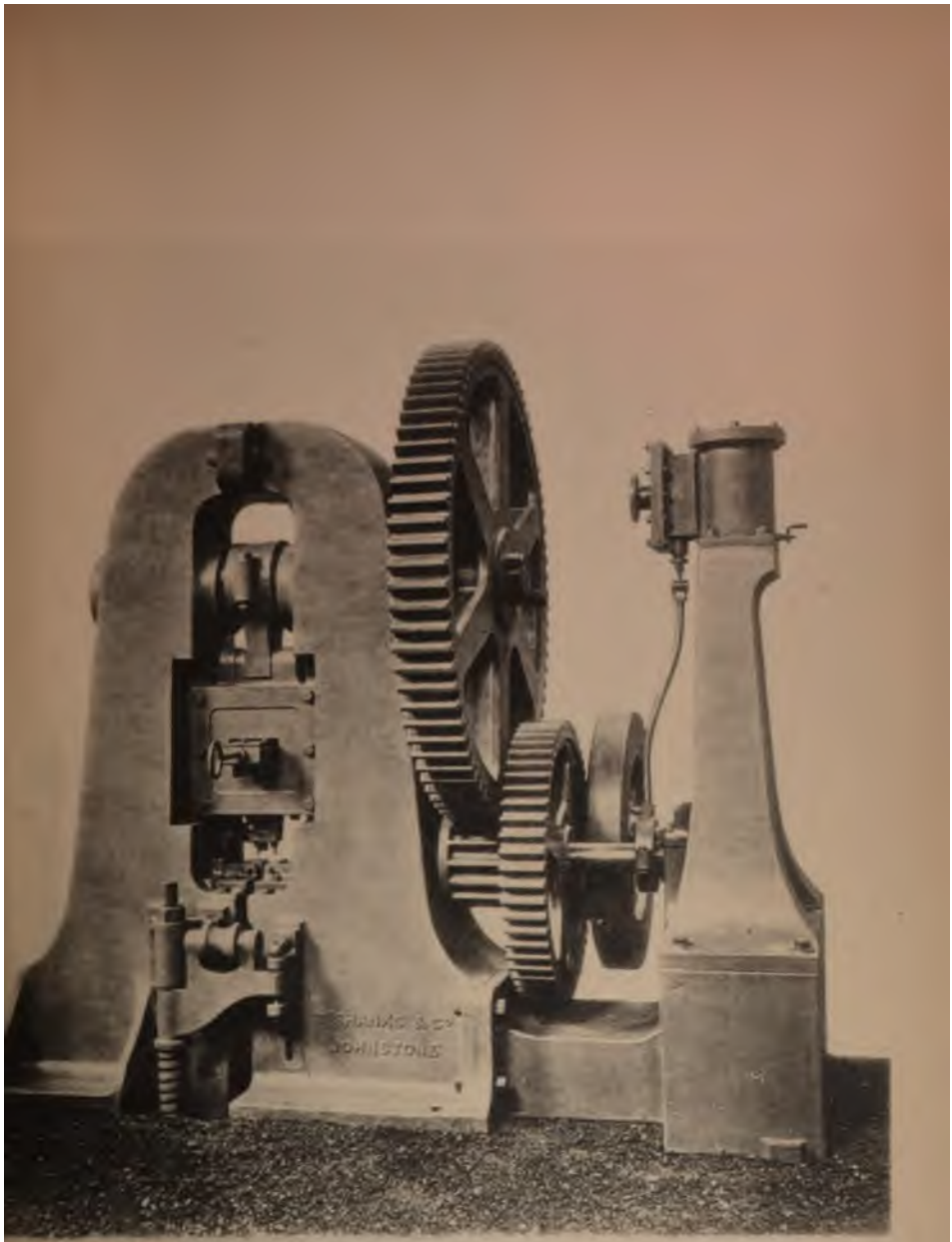

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PHOTOGRAPH No. 4.
MACHINE FOR PUNCHING T BEAMS.
DRIVEN BY ENGINE.

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which have a reciprocating table, worked by a small engine, by belting, or by hydraulic power. Two spuds project from this table, and the beam or frame is squeezed between these and an adjustable block in the center, whose position is regulated by a screw and hand wheel. This tool is often made double ended, so that frames may be set on both sides at the same time, or in some cases one side of the table carries a punch for horizontal punching. Adjustable rollers are provided for regulating the height of the work.

Plating, particularly the light plates of bulkheads, deck-houses and the like, often comes to the building-yard in a condition which requires time, skill, and labor to reduce it to a fair surface. To obviate the cost and delay incident to this process, plate straighteners are in common use. These machines consist of four upper and three under rollers, the upper ones running in bearings, which are in one plane, and are simultaneously adjustable by screws connected by gears; after several passes through these rolls the plates are so straightened as to require little or no hand labor. I present photographs of these tools, as well as of several good designs of bending rolls, adapted to work of different dimensions. These present no novelties. They are substantial three-roll machines. In the larger sizes the adjusting screws in the housings are connected by a shaft and worm gears so as to be operated by power, and to work simultaneously. The best British designs of light rolls with tumbling housing, such as might be useful in the manufacture of iron masts and yards are also illustrated, with their prices.

In common punches and shears no important developments were observed, although it may be worth while to notice the usual foreign practice of driving these machines by engines self-contained with the tool, which may be placed in many situations where it would be inconvenient to carry shafting, while a steam pipe is quite practicable The loss of power in shafting which is continually running, the wear and tear of belting, and the increased liability to break-downs, are arguments to support this practice. In addition, it should be borne in mind that the shear shed is ordinarily a cheap and unsubstantial structure, little suited for keeping shafting in perfect alignment. In such punches and shears the fly-wheel is often placed on the second motion shaft and not directly on the engine; as the wheel is geared to run very fast, the necessity for a large one is obviated, and a more compact machine results.

In punching the flanges of beams to receive deck plating or planks, the beams are liable to be distorted and may require straightening afterwards. A special punch for beams is now made which deals with both flanges at once. I transmit a photograph and prices of this machine by one of the leading makers.

A useful portable punch and shear combined, mounted on wheels for moving about the yard, ordinarily worked by hand with a crank and fly-wheel, but also provided with pulleys, so that when convenient, it may be driven by power, is to be found in some British ship-yards. When made of 4 tons weight, it shears three-fourths-inch plate and punches three-fourth-inch holes through three-fourths-inch plate. The gaps are 18 inches in depth. A similar tool of half this weight punches and shears five-eighths-inch plate and has a gap of 12 inches.

The absence of multiple punches was noted. This can hardly be due to their limited application, as there is sufficient straight line work in bulkheads, tanks, &c., to justify their employment; it is rather to be traced to the fact that they are troublesome to keep in adjustment. Punches with automatic feed were also rare.

In all the best punches a disengaging gear is fitted in the head of the machine, which can be thrown out whenever, through some mismanagement, a bad hole is about to be produced.

Some tools of unusual power were observed. In the Baltic Iron Works, at St. Petersburg, there is a punch capable of piercing 2-inch plate with a 2-inch hole and of shearing steel of the same thickness. It is used on armor deck-plates. The gap is 30 inches and the weight 36 tons. This heavy tool was made by Messrs. Craig and Donald, of Johnstone, Scotland. Most of the large ship-builders are provided with a powerful hydraulic punch for cutting out man-holes and lightening holes. Holes as large as 30" by 21" are cut from three-fourths-inch plate, and there is a set of punches and dies of diminishing sizes. The general arrangement is simple; a ram, which works downward, carries the punch and a corresponding die is bolted to the bed-plate. The latter is attached to the cylinder by four strong columns, as in the common style of hydraulic press. This is a tool of obvious utility where much water-bottom work has to be done.

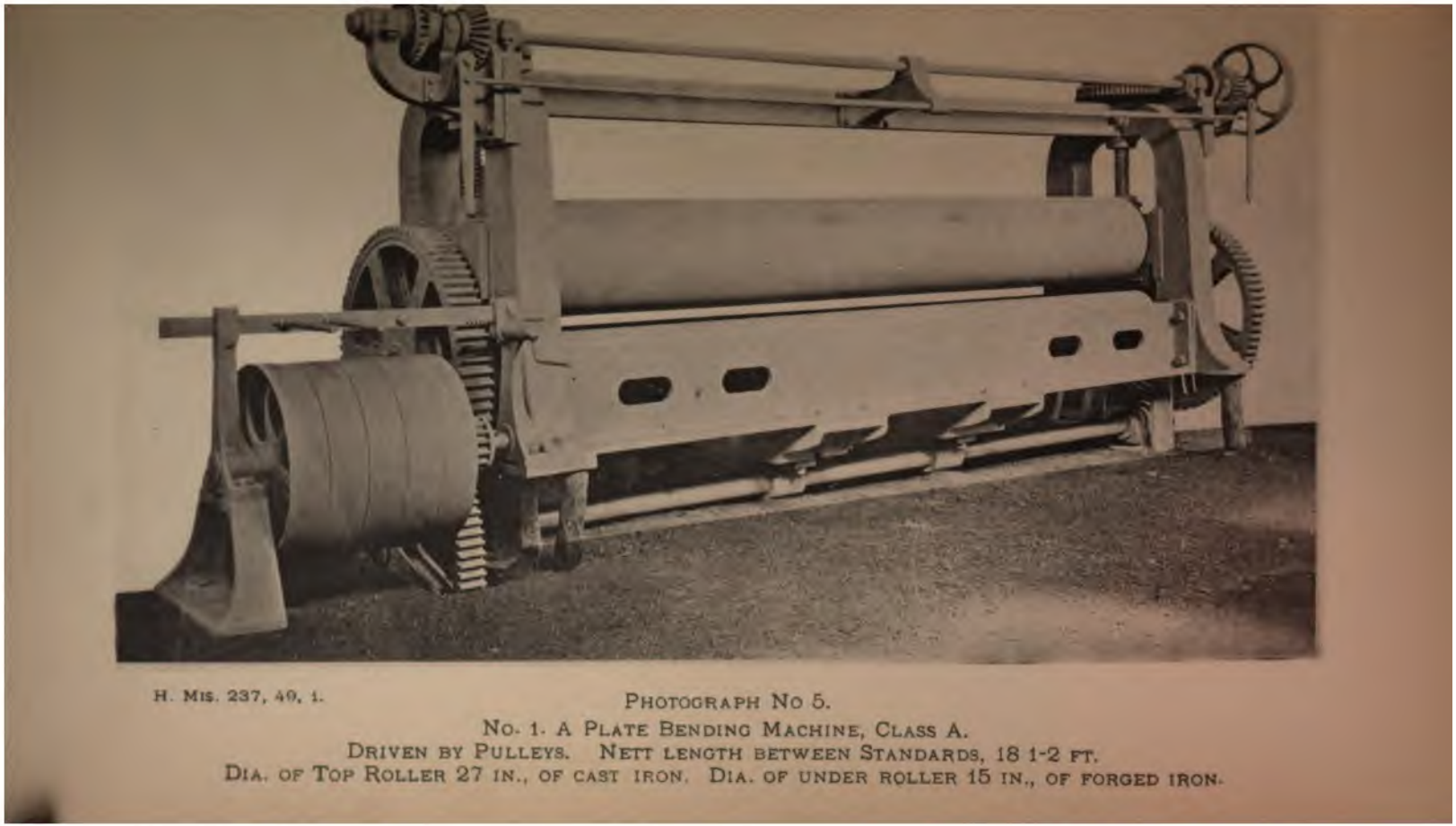
It is especially serviceable on work in steel, as the plate is left in a condition which requires little further attention, while the labor bestowed in finishing the openings, if they come from the small punches, is costly. To fully utilize the strength of steel it is considered important to remove every trace of raggedness or incipient cracks, which is often accomplished in the case of lightening holes in floor plates, &c., by grinding with emery wheels; the plate, which is usually of a manageable size, being moved about on a horizontal table while an emery grinder on a vertical arbor which revolves in fixed bearings, takes off the roughness left by the punch.

Ship-yard machinery is very generally gotten up on the combination-tool principle. It is very desirable to make a "*multum in parvo*" of those machines which are capable of such treatment, and though this may be carried too far, still, in general, an economical and compact plant results. Thus it is common to find two angle shears and two punches, all parts of the same tool; or an angle shear and a cold-setting machine and similar arrangements.

For drilling keel-bars, stern-posts, and stems a large radial drilling machine, having three or more arms with drills, is the best arrangement, the bed plate of the tool being fitted with rollers for carrying the work. For drilling plates or countersinking the same machine is available.

Among tools specially serviceable in the building of war vessels I would mention the band-saw as recently applied to the sawing of thick steel plates, such as we have in armor decks. The work turned out is very neat and it is performed with a fair degree of rapidity.

I have elsewhere mentioned the superior tools being fitted in the extensions of the French dock-yards, more particularly at Brest. The new punches and shears are hydraulic, as well as the cold-setting machines, which are quite different from anything which I have hitherto described. Punches and shears constructed on this plan have few moving parts, and are characterized by great simplicity. The French plant at Toulon is entirely hydraulic. It was laid down in 1876, and has given such satisfaction as to induce later installations in the other dock-yards. The French favor hydraulic tools for all operations upon steel. They believe (I quote the opinion of M. Berrier Fontaine) that the strength of the metal is, in general, better maintained if worked by pressure than when subjected to such tools as operate more or less by impact or



PHOTOGRAPH No 5.

No. 1. A PLATE BENDING MACHINE, CLASS A.

DRIVEN BY PULLEYS. NETT LENGTH BETWEEN STANDARDS, 18 1-2 FT.

DIA. OF TOP ROLLER 27 IN., OF CAST IRON. DIA. OF UNDER ROLLER 15 IN., OF FORGED IRON.

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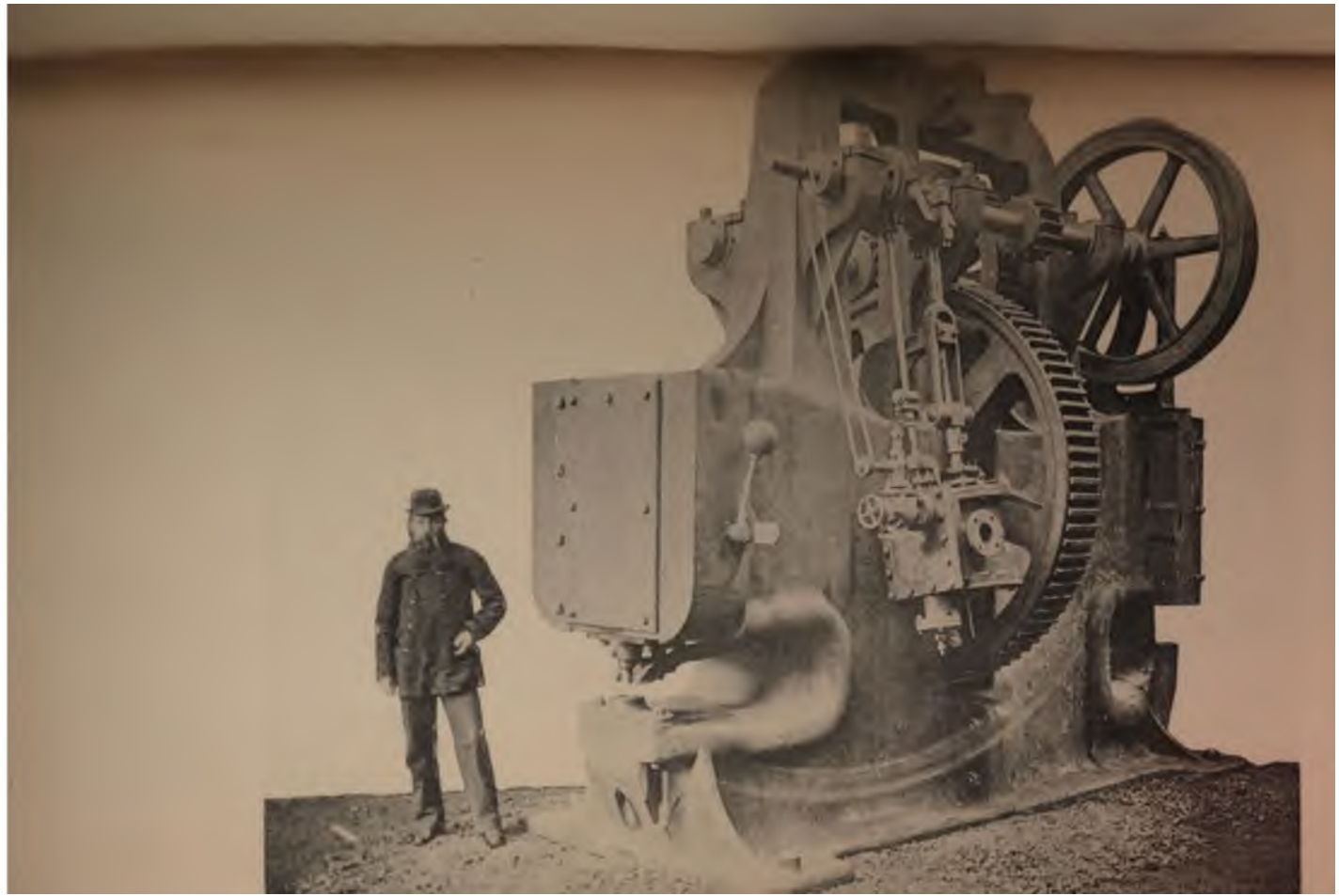

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shock. The tools of the French dock-yards were made by the Hydraulic Engineering Company of Chester under the Tweddell patents.

I am here led to speak of hydraulic appliances in general, which of late years have found a wide and increasing application in ship-building and engineering establishments. In the well-appointed yard there is always a hydraulic house, in which is located a pressing engine. Such engines are supplied by Sir William Armstrong of Elswick, Brown of Edinburgh, and other makers. An accumulator, conveniently placed, loaded by steam or weights, forms a reservoir of power from which mains lead to the several building berths, riveting machines, hoisting appliances, hydraulic capstans, &c.; but the principal use is in riveting. The large gap required in a machine for riveting skin plating necessitates proportions which are at variance with portability, and hydraulic riveters, thus far, have been found available principally for work on frames. Two portable riveters, hanging from cranes at the head of the building slip, receive their water through a flexible copper pipe. They operate on the frames which are laid across the keel on trestles in the usual manner. The frames are rapidly completed and moved down the keel to their appropriate stations and hoisted into place. The average performance of such machines on simple work is fourteen hundred rivets per day of nine and a half hours.

The pressure frequently used in the machines is 1,500 pounds, but there is a diversity of opinion as to the best pressure for working hydraulic tools, some establishments being provided for 700 pounds and others for 2,000. Keel riveters have also been applied by Mr. Tweddell, and I am informed that the keels of the Alaska, Servia, and City of Rome have been riveted by this means.

Repeated tests of hydraulic riveting have shown the superiority of the work to be beyond controversy. With heavy rivets, such as 1 and 1⅛ inches, which make laborious and defective work when hand driven, the excellence and economy of the hydraulic system is very manifest; and the fact that in keels a conspicuously longer rivet can be used, when machine driven, shows that the holes must be much better filled, and speaks volumes for the superiority of machine work.

Clever hoisting appliances, for raising frames and general use at the building slip, are made to operate by hydraulic power: these are sometimes windlasses and capstans, such as have been previously noticed, but a good form is a simple vertical chamber and plunger having a stroke of 6 or 7 feet, and fitted with four or five sheaves at the bottom, and also at the top of the plunger, over which a flexible wire rope is rove. The standing part of this rope is attached to the machine; the free end may be made fast to any other rope for hoisting, or to any object which it is desired to move. The fact that these appliances entirely do away with the small steam hoisters, which are both dangerous and expensive, should be sufficient recommendation wherever there is a hydraulic plant already established; and the general simplicity of the hydraulic system, the fact that it is always ready to work, without blowing through of steam pipes and losses from condensation and friction of shafting, and its advantages where great power has to be transmitted by a compact and portable machine, are strong arguments for its adoption. Nor is it only for heavy work that this system is valuable. I saw many of the light cranes in smiths' and boiler shops, such as deal with weights of from 10 to 30 cwt., fitted with neat applications of hydraulic power. To cranes the system is peculiarly applicable on account of the simplicity of construction which results, the great weights which may be lifted without resorting to cumbrous ma-

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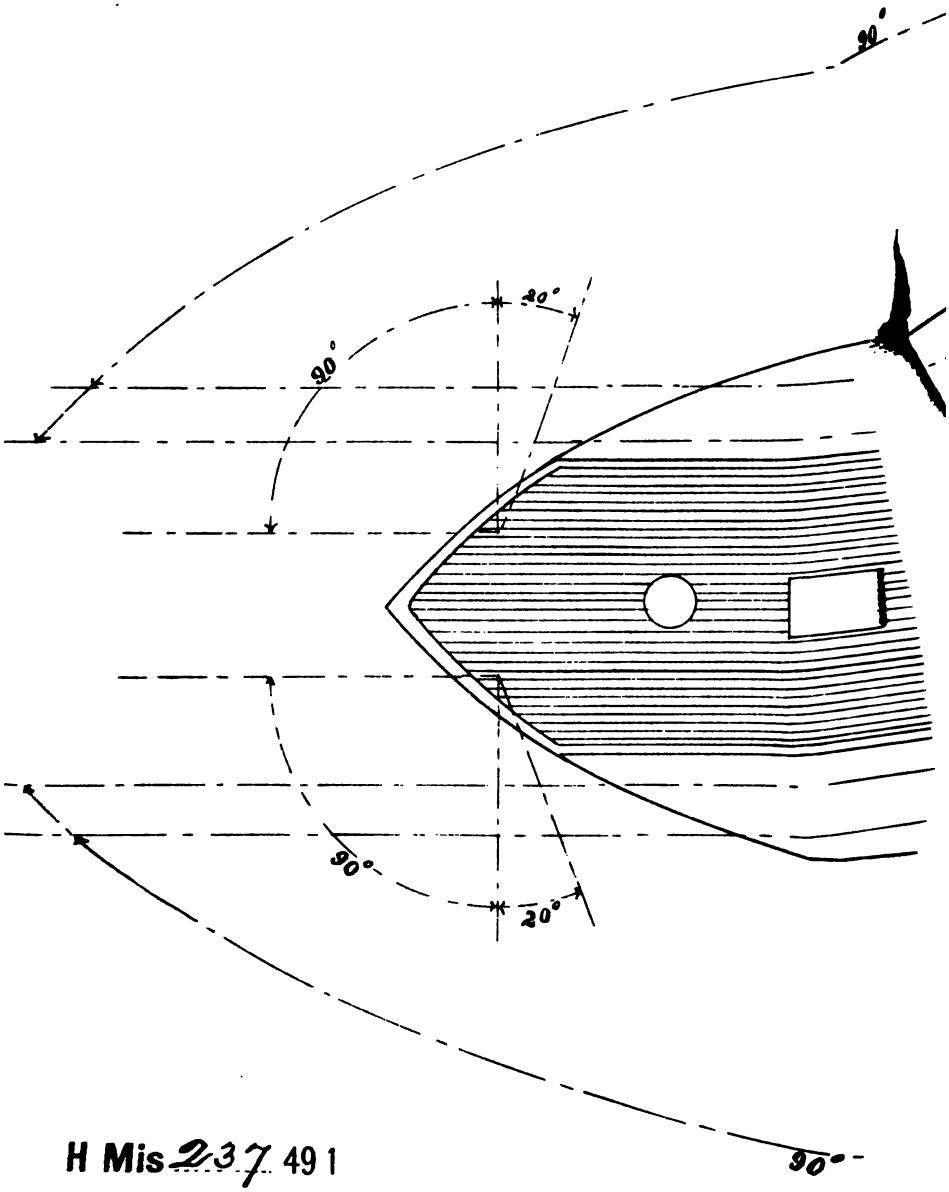

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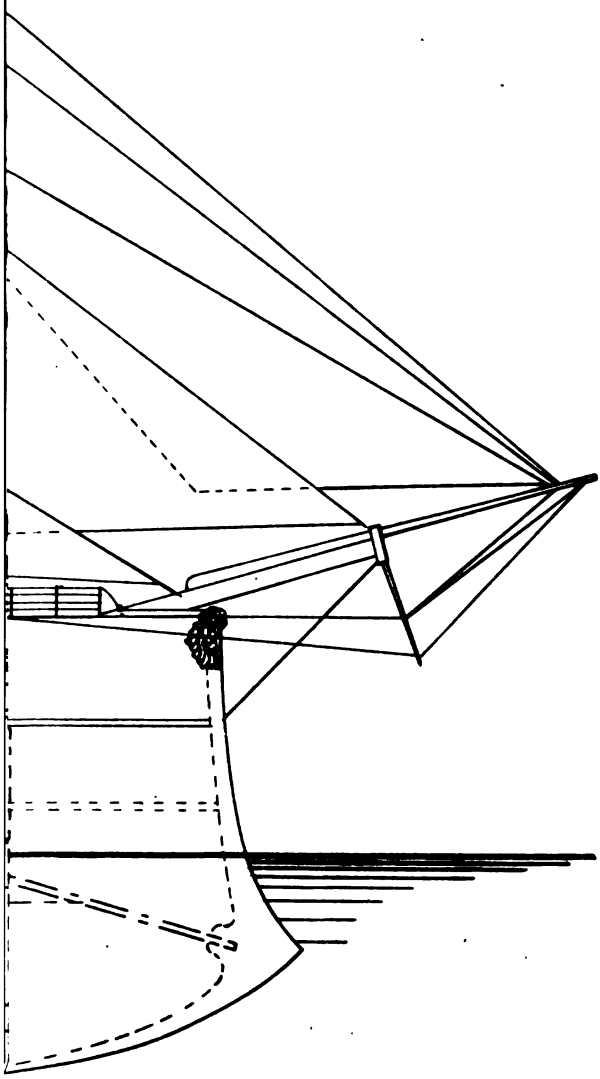

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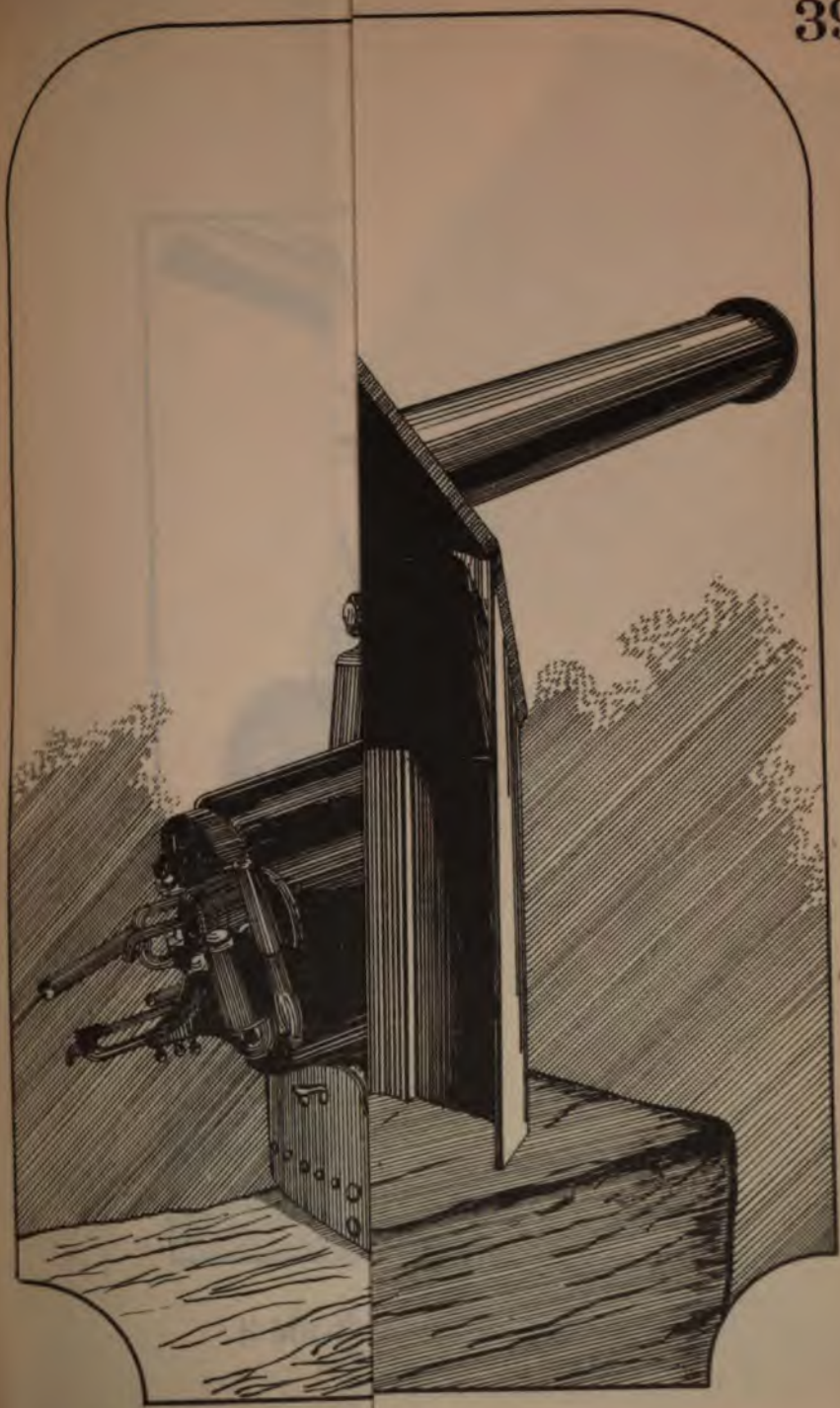

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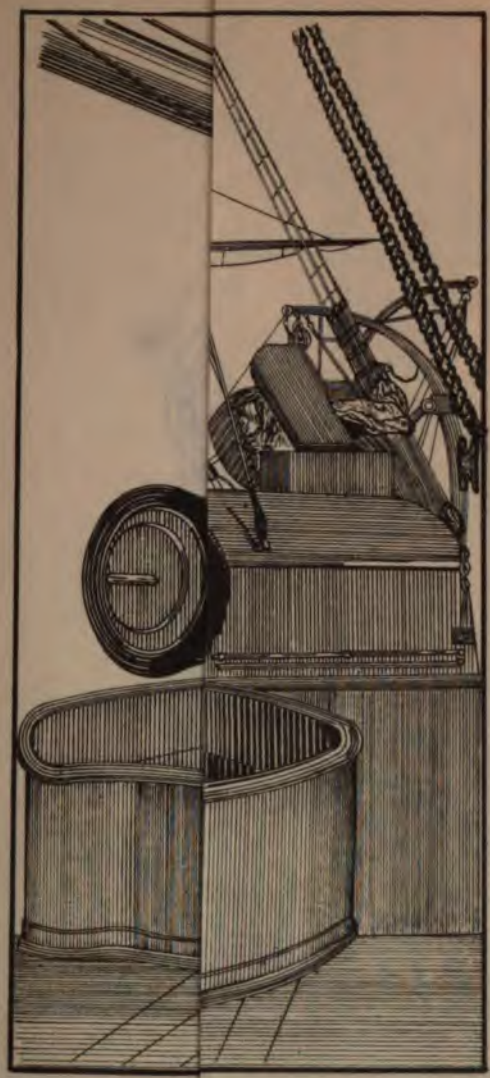

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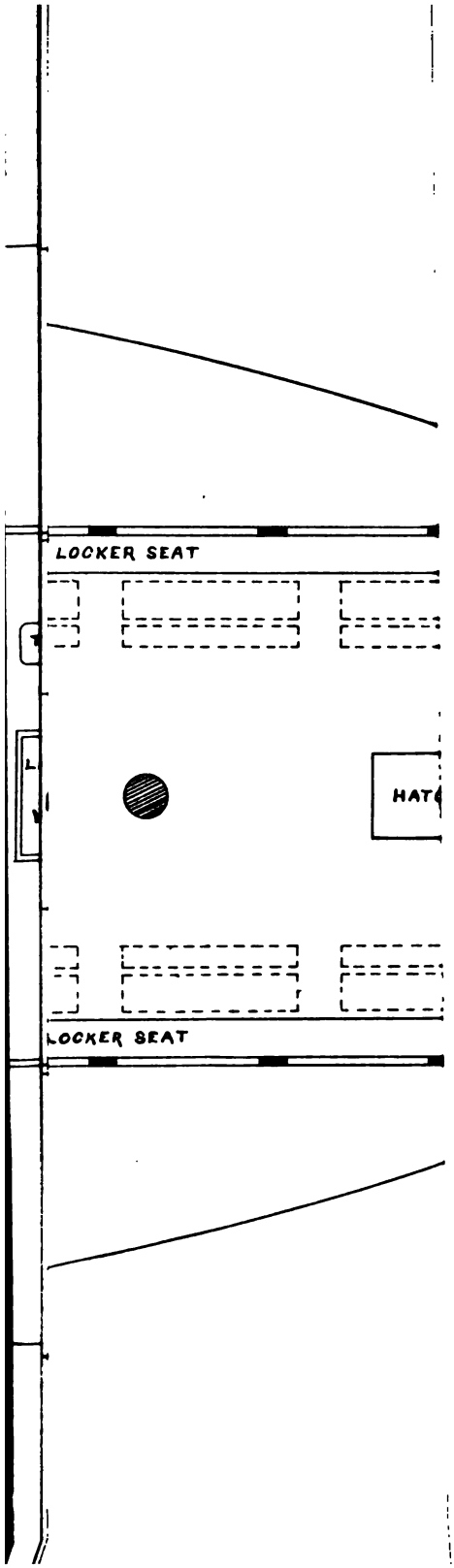
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MESSRS. PALMER'S YARD.

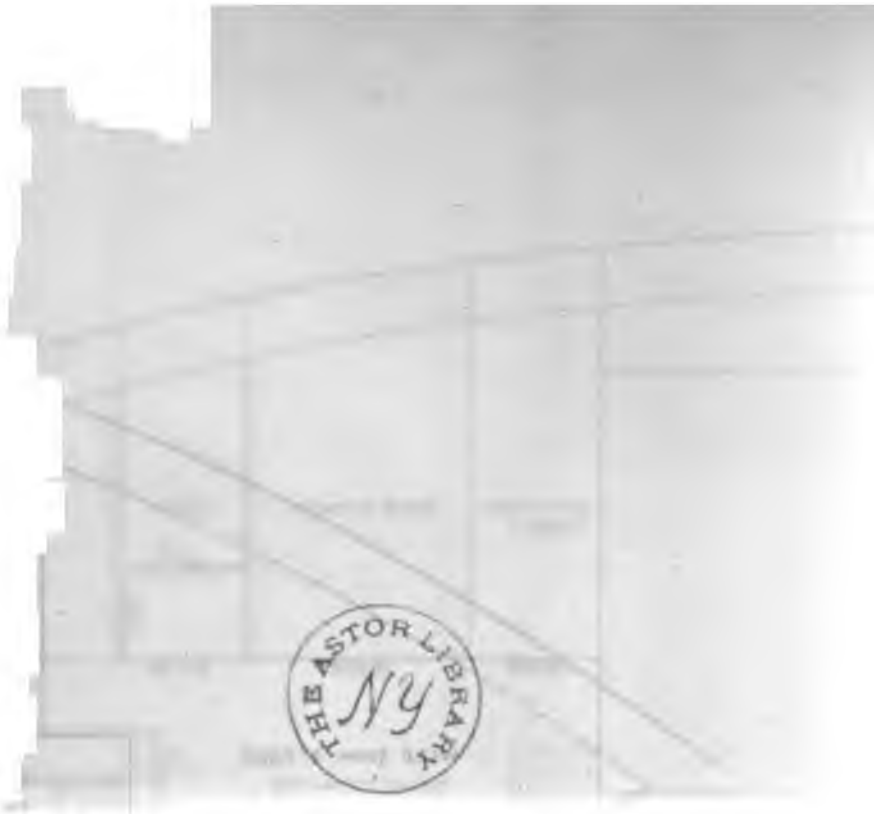
The British Government, early in 1884, gave contracts for several fast steel dispatch vessels, intended for a speed of 17 knots. Two of these, the Surprise and Alacrity, I found partly framed in the yard of Messrs. Palmer & Co., at Yarrow, on the Tyne. They are twin-screw vessels of about 1,4 0 tons, 250 feet in length, 32 feet 6 inches beam; 18 feet 6 inches deep, and 3,000 I. H. P. under forced draft; with natural draft the I. H. P. will be about 2,000. The cylinders will be 26 inches and 50 inches by 34 inches stroke. Z-bars are used throughout for frames the spacing of which is 2 feet. There is a steel protective deck, and the principal hatches are guarded by coffer-dams. The vessels are entirely of steel, manufactured by the Consett and Bolton Companies and by the Steel Company of Scotland.

The firm of Palmer & Co. have built about 475 vessels, and during the year 1883 attained the enormous output or 36 ships, representing a tonnage totality of 61,113. As this company is the largest ship-building concern in England, having its own collieries, ore-pits, and rolling-mills, I submit a plan of their extensive works, which cover an area of nearly a hundred acres, situated about 6 miles below Newcastle. The foundations of this enterprise were laid in 1853 by Messrs. C. W. Palmer and George Palmer. In 1865 the limited company was organized, with Mr. C. M. Palmer as chairman and Mr. John Price as general manager, and their business has since made great and steady progress.

The ore, most of which comes from near Whitby, is brought around by sea, and coal is derived from the company's collieries in Northumberland and Durham. The smelting is done in three blast furnaces, each 85 feet in height and 24 feet bosh and 8½ feet hearth, producing in the aggregate 1,400 tons of pig per week. Usually three-fourths of the product is consumed in the establishment. The plan will show the position of these furnaces, also that of the kilns in which most of the ore is calcined. The furnaces are worked with a blast of 5 pounds pressure and a temperature of 1,100° F. There are eighty puddling furnaces, the weekly output of which is 1,000 tons. There are two plate-mills, 24-inch rolls, capable of turning out 1,200 tons per week. A third pair of plate-rolls has a capacity of 300 tons per week. There are several bar and angle mills and also a sheet-mill.

The machine shops are suitably equipped for the heaviest work in marine engines, and from thirty to forty pairs can be built in a year. The tools in this department are by the best makers, and some are of very large size. I would mention in particular an 80-ton lathe by Muir, of Manchester; some tools of peculiar design by Shanks, of Johnstone, are to be found here. Everything in the way of forgings and castings, either of iron or brass, is made in the establishment. There is a large boiler shop, and among the tools is a vertical bending machine for working boiler plates. Vertical rolls are much preferred over horizontal ones, as avoiding the distortion which the plate undergoes, when worked in the latter, from its own weight. This tool was built by Scriven, of Leeds. The boiler-shop contains two of Tweddell's fixed hydraulic riveters. In the forge there are steam-hammers appropriate for large or small work.

The plan shows a dock which is said to be the largest on the north-east coast; there is also an improved hydraulic railway. There are nine berths for building vessels, besides a number of slips which the company possesses on the opposite bank of the Tyne. When busy the firm employs about 7,000 men. During the years 1881, 1882, and 1883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MESSRS. J. & G. THOMSON.

The tracks of the North British Railway extend into the yard, and the raw material passes from the railway cars to a large building, which contains most of the ship-building tools. It is 550 by 150 feet, and in it are the punching, shearing, drilling, and countersinking machines, plate benders and planers. Here also is a special flanging machine for keel plates, devised and built by the firm, and operated by hydraulic power, with which the yard is amply supplied. The pressing engine is one furnished by Brown, of Edinburgh, whose recent improvements in hydraulic appliances meet with great favor. The Tweddell system of riveting is extensively used. There is a fine smith shop, 600 feet in length and 60 feet in width, with over one hundred fires, and an ample equipment of hammers, including a large one capable of forging stern-posts and other large pieces. At both ends of this shop there are heating furnaces for frames and plates, and bending slabs.

The firm has excellent machine shops both at Dalmuir and Finneston street, Glasgow. They have all the necessary saw-mills, joiner's, carpenter's and cabinet maker's shops, and among their wood-working tools many were noticed of American manufacture, those of Fay & Co. being prominent. There is also an extensive boiler-shop, in which was found an efficient boiler-building plant, comprising flanging machinery and machines for drilling boiler plates in place; punching, in Great Britain, being almost discarded for this sort of work. All of the shops mention are fitted with the electric light, both the arc and incandescent systems being employed.

There is a tidal basin where vessels receive their machinery and spars, and complete their equipment. A three-legged shear, built by Taylor, of Birkenhead, stands at one side of the basin, and is capable of lifting 120 tons. The heel of the back leg travels in a groove by the aid of a long screw; light and heavy purchases are fitted, and the addition of two gaffs to the outer legs makes this shear very convenient for every kind of hoisting.

There are eight building slips, and owing to the conformation of the river, launching facilities are possessed by this firm which are exceptional in the upper yards of the Clyde. Numerous girls are employed in making tracings and in French polishing the finer sorts of joiner work.

THE SCOUT.

When I visited Clydebank, the Scout, a steel torpedo-ship of an entirely new type, was being built for the British Government. Her length is 220 feet; breadth, 34 feet; depth, 19 feet, and displacement, 1,430 tons. She has twin screws, and her engines are expected to develop 2,100 indicated horse power, or, with forced draft, 3,200, which should give her a speed of nearly 17 knots. About 400 tons of coal are carried, which will be sufficient for steaming 7,000 knots at 10 knots speed. She will be protected by a light steel deck of segmental section about 100 feet in length, extending over the machinery spaces. The machinery is further protected by coal. The twin-screw engines are both in the same engine-room; the four boilers are placed in two water-tight fire-rooms. There will be eleven torpedo-tubes, and, in addition to torpedoes, which will be her special means of attack, she will be armed with four 5-inch guns and eight Nordenfeldts.

The frame is entirely of Z-bars, and I noticed that in the difficult

work around the shaft-pipes they showed but little strain and s
admirably worked. A double bottom is constructed under the e
and boilers. An unusual feature in this vessel is that the floor
and intercostals are galvanized, but the clips are not. There w
light schooner rig. The cost of the Scout is stated to be £66,00
side this vessel an amount of merchant work was in progress, in
a large ship for the Beaver Line and a freighter for the Wes
trade.

Messrs. Thomson have produced about two hundred vessels,
gating 300,000 tons, and among their elegant collection of t
models are to be found those of such well-known ships as the
Servia, Aurania, and America.

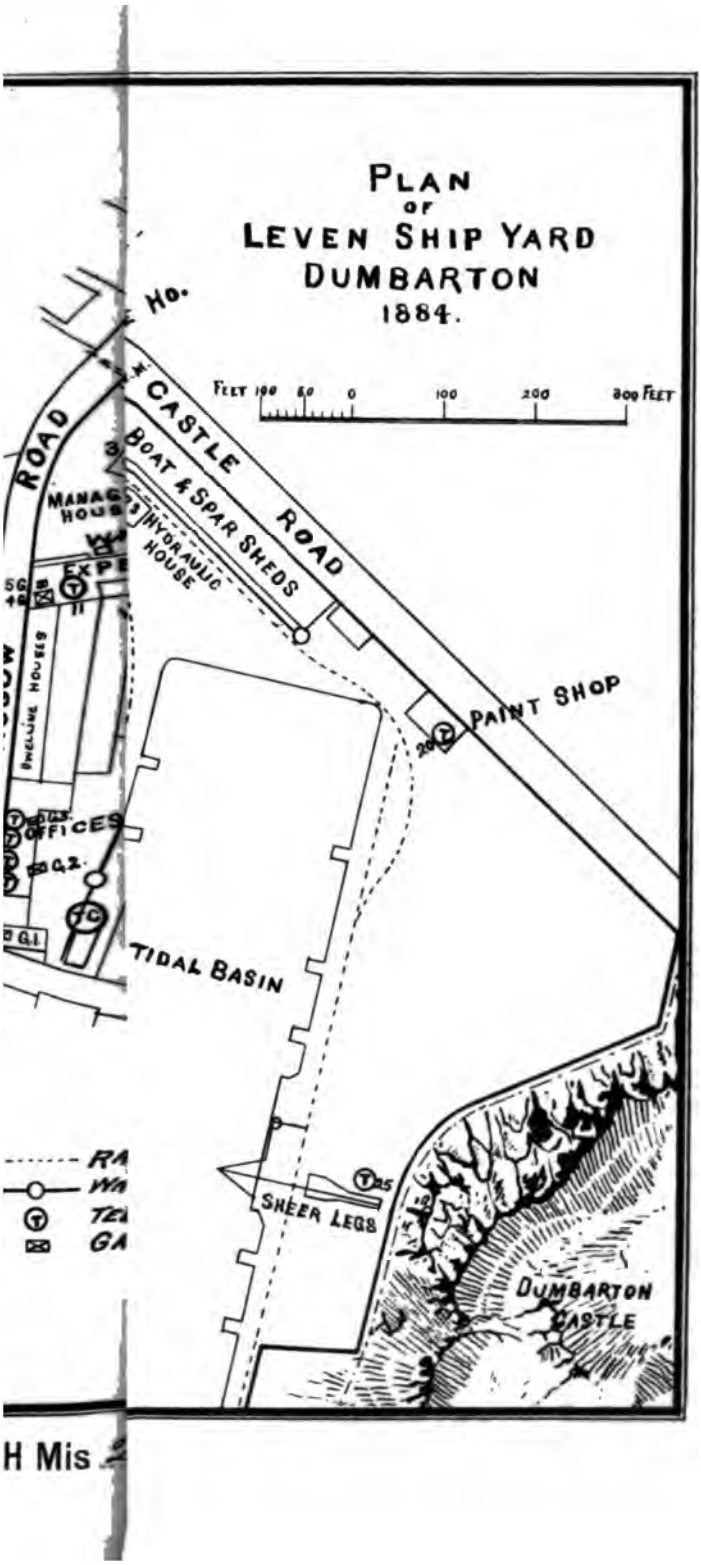
MESSRS. DENNY'S YARD.

One of the most widely known and scientifically conducted y
the Clyde district is that of the Messrs. Denny, of Dunbarton. T
of their ship-building yard, herewith presented, illustrates its
arrangement and includes the recent improvements, which ha
of an important character. The property is advantageously s
on a bend of the river Leven, near its confluence with the Clyde.
are 43 acres of improved ground and a reserve which has not
been occupied. The plan, which is made to scale, will show the
dimensions of the different buildings, many of which are one s
height. Corrugated iron, worked in arched bays of 25 or 30 f
resting on wooden lattice rafters, is much used in the roofs o
structures. The plan will also show the systems of water-mai
telephone circuits as well as the railway communication through
yard, in addition to which there is an extremely convenient porta
way of narrow gauge, which can be taken up and relaid in a ver
time. This is used for carrying plates and frames between th
and the various building berths, and is an arrangement whic
commend itself to all who have seen men carrying heavy portic
vessel through ship-yard mire on an ordinary two-wheeled trucl

A system of hydraulic mains extends to the several buildir
from a central hydraulic house, where one of Brown's pressing
supplies power. There are two tidal basins, one of which, of larg
city, has just been completed, and is furnished with a shears for
100 tons, built by Day & Summers, of Southampton.

The vessels are designed in a drawing office, or rather a s
offices, whose outfit and facilities are very complete. I was here
many ingenious devices for aiding the work of the office, includ
improved integrator recently made for the firm by Amsler, of
The drawings are all kept in a large fire-proof room; and co
with the drawing office there is a well filled library of technica
ture, to which the draftsmen can refer upon such questions
arise. Girls in considerable numbers are employed by the
Denny, some as assistants to the draftsmen, and others in the upl
and such departments involving light work.

In connection with the design of vessels, especially vessels
speed, Messrs. Denny are deeply impressed with the importanc
experiments inaugurated by the elder Froude, and now so ably ex
by his son. One of the latest developments of Leven ship-y
been the construction of a tank, similar to the well-known arran
at Torquay. No expense has been spared, and the proprietors
congratulated upon having availed themselves to the utmost
vious experience to which they have added improvements of the


PLAN
OF
LEVEN SHIP YARD
DUMBARTON
1884.
FEET 100 50 0 100 200 300 FEET
CASTLE ROAD
BOAT & SPAR SHEDS
HYDRAULIC HOUSE
PAINT SHOP
OFFICES
TIDAL BASIN
SHEER LEGS
DUMBARTON CASTLE

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The tank is contained in a suitable building, and is approximately 350 feet in length, 30 in breadth, and 10 in height. Close to the water, and suspended from the roof, at short intervals, by rods, are two stringers carrying rails on top, forming a narrow-gauge railway, extending the whole length of the tank. On these rails the truck runs bearing the dynamometer, and drawing the model through the water. The model is kept straight, and is allowed a vertical and fore-and-aft motion but no lateral movement, through the aid of a frame or harness, by which it is connected to the truck. The truck is drawn by a wire rope which passes over the drum of a small double engine. Uniformity of speed of the engine is secured, or rather is sought, for the device has not been wholly satisfactory, by a hydraulic governor. This operates upon the principle of the cataract. A small pump, driven by the engine, supplies water to a cylindrical chamber in which a plunger works. Leading from this chamber is a discharge orifice, regulated by a cock. The plunger connects with the throttle, and governs the supply of steam to the engine, and the movement of the plunger is controlled by the waste-cock. When the latter is adjusted to secure a certain velocity of the truck, if the engine speeds up, more water is pumped into the chamber than the overflow will pass, and the plunger moves out, closing the throttle; or, if the engine slows, the pump sends in less water and the plunger, in obedience to a spring which presses it back into the chamber, partially closes the valve.

The mechanism which Messrs. Denny have had constructed, at considerable expense, for producing the models from the lines is very interesting. First, a mold is roughly made in clay, contained in an oblong box, a few sections of the vessel being used in sweeping up. An allowance for finish of about three-eighths of an inch is given. A core made of laths tacked against a few approximate sections, is covered with cotton cloth, and is so proportioned as to give a thickness to the finished model of an inch or an inch and a quarter. When the core is prepared and put in place, the material for the model, which is paraffine with a sufficient admixture of wax to give it the desirable qualities, is melted in a tank placed over a row of gas jets, and run into the mold. The core is easily broken out, and by pouring water around the model and making a few incisions with a knife between the paraffine and the clay, the liquid quickly insinuates itself and the model may be lifted out. For purposes of comparison models are made of a uniform length of 12 feet.

The copying machine to which the model is now transferred, is of elaborate and apparently complicated construction, although the underlying principles are quite simple. A table, like that of a planer, carries the work, which is secured keel upwards. Two rotary cutters revolve on vertical spindles above it, and are operated through such mechanical movements as compel them to approach or recede symmetrically as regards the fore-and-aft central plane of the ship, while the table travels to and fro. The cutters are adjustable vertically to reach the different water lines of the ship, and their inward and outward movement is brought about in a manner which I will now describe. Placed on its edge along the side of the machine is a board on which the lines of the vessel are mounted. It has a motion coincident with that of the table, but of adjustable amplitude to accommodate sets of lines of different lengths and reduce or expand them to the standard 12-foot model. A pointer, moving vertically in guides, is governed by a hand wheel to follow each water line as it passes behind it, and this motion is transmitted to the cutters and causes them to approach or recede in the man-

ner described. A lense is fitted over the pointer for following the lines with more precision; and as the movement of the pointer corresponds only with that of the center of the cutters, and not with that of their periphery, which is describing the lines of the model, it is necessary to attach to the point a semicircular plate, which shall take into account the radius of the cutters, or, to be yet more accurate, a semi-ellipse which shall make correction both for the radius of the cutters and the ratio of contraction; and it is the perimeter of this plate which is made to follow the water line on the board. When the work leaves this machine it exhibits a series of steps, corresponding to the lifts of an ordinary wooden model. It is next worked down and finished by spoke-shaves and appropriate tools. To strengthen the paraffine shell and provide a point of application for the dynamometer several wooden thwarts are fitted.

In all essential particulars the dynamometer is similar to Mr. Froude's, of which frequent descriptions have appeared, and which I afterwards observed at Torquay. As in that apparatus, resistances are recorded on a paper wrapped on a cylinder which makes a whole or a partial revolution according to the length of the run; pens are provided for automatically recording on the same paper equal intervals of time and distance actually traveled by the truck, also distance traveled through the water, as given by two delicate current meters; other pens are used in special experiments. A series of springs of assorted strengths are used to record the resistance under different conditions of speed; but their reading is always checked by the test of weights actually applied to the arm of the dynamometer. The line indicating the resistance, even when every precaution has been taken, is very irregular; every portion of the mechanism seems to have its own period of vibration and leaves its mark. To correct this and trace a mean line of resistance is the duty of a number of girls, who take the cards and, striking an approximate line, determine by planimeters, measuring the area cut off on either side, whether or not it is sufficiently accurate. This work is done in an office attached to the tank where records are kept and tables made out of the results of the numerous runs.

Of the shops and tools of Messrs. Denny it is unnecessary to speak further than to say that they are similar to, and fully up to the standard of the yards previously described. Their fine engine works, situated at about half a mile from the ship-yard, were in process of extension; and the main shop, when completed, will be 500 feet in length. White glazed bricks are being used in the interior of this large building, and will add much to the light as well as to the neatness of the shop.

The work going on in the ship-yard was of a varied character; several light draught side-wheel and stern-wheel boats were constructing for China and India; a small yacht was being built for the colonial government; the Arawa, a superior vessel for the New Zealand trade was about to receive her machinery, which will be compound with triple expansion, working steam at an initial pressure of 160 pounds. She was fitting for the transportation of meat, and had refrigerating machinery on board. The holds were lined with charred shavings back of the ceiling and the deck beams, and stanchions were similarly inclosed in non-conductors. The only paint used on the inside of the plating, and frames was a couple of coats of cement and sour porter, the surface having been first prepared with a wash of sal-ammoniac.

The three yards thus sketched may be regarded as representative ones of this district; while there may be others equally excellent and a number not much inferior, I feel that it would involve much needless repetition to describe them.

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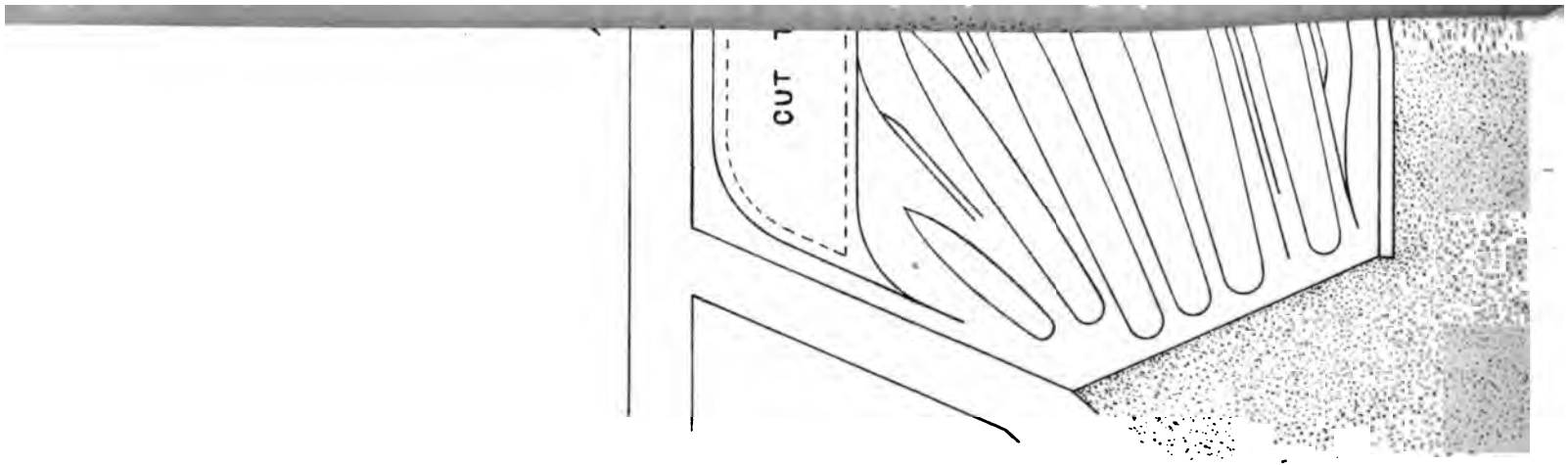


HARLAND AND WOLFF'S SHIPYARD, BELFAST.

H Mis 237 49 1

MESSRS. HARLAND & WOLFF.

But before taking leave of the subject of private yards, I would mention the superior establishment of Messrs. Harland & Wolff, at Belfast, Ireland, which occupies about 50 acres of land on the peninsula known as the Queen's Island. The present establishment may be said to have been founded in 1859, when Mr. E. J. Harland acquired the premises of Messrs. Hickson & Co., with whom he had previously been manager, as well as the yard of the Belfast Shipbuilding Company. In 1861 Mr. Wolff became a partner and the firm has since been increased by the accession of Mr. W. H. Wilson and Mr. W. J. Pirrie, both of whom grew up in the establishment. The extensive business which this yard has enjoyed for many years will be seen from the following statements: In the five years ending with 1864 thirty vessels were built, amounting to 30,276 tons; in the next five years thirty-six vessels, aggregating 28,023 tons; in the next five years, ending with 1874, seventeen vessels and 46,283 tons; in the next five years forty-four vessels and 57,068 tons; and in the five years ending with 1884, forty-two vessels and 105,068 tons. In this is included a number of vessels for Her Majesty's navy, among which may be mentioned the gun-vessels Lynx and Algerine, and the torpedo-ship Hecla.

In 1870 they constructed the Oceanic, the pioneer of the fine transatlantic fleet of the White Star Line, and since that date they have built for Messrs. Ismay, Imrie & Co. twenty vessels, amounting to 75,000 tons.

The location of the works is excellent, the slips being at each end, while between them are situated the workshops. A narrow-gauge railway intersects the works in all directions, and connects the various shops.

The offices are very extensive, and a larger force of clerks and draftsmen are employed than I have elsewhere observed. The drafting, particularly, was carried out with an extraordinary attention to detail; and their system of accounts, which was courteously explained, evinced a methodical completeness seldom met with.

Many of the buildings are of wood, this material being preferred because, among other reasons, the treacherous nature of the ground has made foundations a source of great expense and trouble. The shops are detached from each other and communicate in the second stories by bridges, which are contrived to be easily thrown down in the event of fire. As many as 4,000 men are often employed by this concern, which is self contained to a very great extent, and manufactures for itself most of the outfit of its ships. The upholstery, cordage, and sails are all made by the establishment. There is a large engine-shop and a foundry, both of which are well arranged. There are eleven building-slips, adapted for vessels of the largest size. Three of the finest slips have just been finished at an expense of £6,000 each, so great has been the amount of piling necessitated by the soft character of the ground.

The method of carrying out work is original, and, so far as I have observed, different from that of any other firm in the United Kingdoms. The system of contracting, in which the quartermen of the yard will offer to put in such bulk-heads, or lay such decks, or do given jobs of riveting, &c., for a definite price, almost universal in other yards, is, in the practice of Harland & Wolff ignored; and with the exception of less careful work, like riveting of frames, is never resorted to. In this matter considerable superiority of workmanship is reasonably claimed

to result. In manufacturing so much of their own outfit they
seek profit, which in moderate manufactures of this sort cannot a
so much as the control which they thus possess over the quality
material entering into their productions. As another matter in
this firm was found to be unique, I would mention that, of the se
eight vessels building at the time of my visit, four were bein
structed on the unusual basis of charging the time and material
percentage of profit for the builders.

A good stone dry-dock, owned by the city of Belfast, is adjac
the property of Harland & Wolff, and a three-legged shear, of 8
lifting capacity, is near by, and is also city property, though bui
much used by the firm.

AGEMENT OF WORK AND EMPLOYÉS AND THE EDUCATION AND PROMOTION OF THE PERSONNEL.

British private yards the bulk of the work is given out to the men all contracts. Day wages seldom amount to more than from 60 to r cent. of what the same trades receive in the United States. In yal dock-yards the matter of wages is somewhat amended; most labor is day work, and the employés have considerable attention to their comfort—about one-third of the men are called "estab-l," and have a pension to look forward to when advanced in life ncapacitated—a wise provision, encouraging good conduct on the of the men, and rendering a strike in the dock-yard an impossi-. The average hired man in the Government yards gets 3*s.* 5*d.* ay, and the average "established" man gets 4*s.* 6½*d.* A leading-of shipwrights gets 6*s.* 6½*d.*

both public and private yards the men are subject to formidable of regulations, and in the latter the rules are particularly stringent. ne is usually kept on the ticket system. Every man is known by nber, stamped on a metal check, which he takes from a box on ing the gate and deposits on leaving. Sometimes this check is a en tag, having the number on the front, and on the back a silicate on which the workman writes briefly the name of the job on which s been employed.

hours of labor in the royal dock-yards vary with the season of ear. In the private concerns of England the week's work is made fifty-six hours. The workmen come at 6 a. m. and work till 8, they have half an hour for breakfast. At noon they take an hour. aturdays they stop at 1. Time and a quarter is usually paid for ime.

France wages are extremely low, and the condition of the work-an is correspondingly depressed. In the dock-yards laborers get 30 cents per day; blacksmith's helpers, 35 to 45 cents; a second-shipwright, 45 to 55 cents; and a very competent shipwright may cents. Average blacksmiths, fitters, and turners get about 60 . A competent smith will get 80 cents. After years of service, looking forward to becoming a foreman, he will get $1 per day, but reman gets more than 8 francs or $1.60. After twenty-five years' yment every workman is entitled to a pension, which is two-thirds greatest pay. This pension is what most of the employés are look-rward to, and it does much to reconcile them to their rather forlorn tion. In the summer months they work from 5 a. m. to 7 p. m., ing from 8 till 8.30 and from 12 till 1.30. In winter the hours of are from 6 a. m. till 5 p. m., with a half hour for breakfast and an for dinner.

some private establishments and in many dock-yards, both in nd and France, a large room is fitted up as a place where men can and eat their dinners in warmth and comfort. In these rooms -ovens are sometimes provided in which dinners can be warmed attendant. I consider this a praiseworthy arrangement, and one conduces greatly to a cheerful and contented working force.

Much attention is devoted to water-closets, which are seldom filthy sheds, overhanging the river, but well kept and cleanly and under strict surveillance. The regulations of private yards as to time spent in latrines are rigid and almost severe. In many cases the entrance is through a little office, where a clerk keeps account of every man's number and his time; and in one establishment this was carried to the refinement of making out weekly averages for every employé. Fines are imposed for unnecessary delay, and, like most penalties for infringements of yard regulations, the proceeds are devoted to a charitable fund. I here insert the rules of a well-known Clyde firm.

RULES OF GOVAN YARD.

All piece-workers and their helpers, and time-workmen are engaged on the condition that they shall observe the following rules or forfeit the undernoted penalties.

All fines shall be paid to the accident fund, and the amount will appear yearly in the account of that fund.

I.—GENERAL.

(1) Each piece-worker, piece-worker's helper, and time-worker, who is not paid an upstanding wage, shall be known by a number, as well as by name, and shall take from the time-keepers a ticket with his number on it each time he enters the yard, and shall place it each time he goes out of the yard in the box corresponding to the ship he is at.

Time-workers will be provided with tin tickets and piece workers and their helpers with brass tickets.

All vessels being built will be known by numbers. Repair jobs, and such yard accounts as are to be kept separate, will be known by their names. For each of these a separate box will be provided for receiving the tin tickets at the time-worker's entrance, and at the entrance of the piece-workers and their laborers similar boxes will be provided for the brass tickets.

All employés on first receiving a ticket shall have their time rate of pay fixed by the foreman. This rate will be entered in the new worker's rate-book, and any piece-worker, piece-worker's helper, or time-worker failing to take and put in a ticket as above described shall be liable to have time taken off him at the rate of pay against his name.

(2) Any person depositing his ticket in the wrong box shall be fined threepence for the first offense, sixpence for the second, and one shilling for each time afterwards.

(3) In the case of a piece-worker or piece-worker's helper being fined, the sum will be deducted from the earnings of the squad he is associated with, and intimation given to the head of the squad before the pay takes place.

(4) The subscriptions to the accident fund will be assessed at these rates; those who do not wish to join being required to give intimation to this effect.

(5) Whenever a time-worker goes on piece he must give up to his foreman his time ticket, who will give him a note to the time-keeper to give him a brass ticket. The foreman will then put on record the terms on which the contract work is to be done. Any one losing or destroying a ticket shall be charged threepence for a new one.

(6) The time-keepers will be in their ticket-offices fifteen minutes before each time of commencing work. Five minutes after the bell has rung for commencing work in the morning, and when the bell has ceased ringing after meal hours, the time-keeper will mark each man who comes in from that time until fifteen minutes after the bell has stopped, and shall deduct from the pay of the time-workers half an hour, and of piece-workers and their helpers one-quarter of an hour, at the rate of pay against their names.

Fifteen minutes after the bell the workmen's gate will be closed, and no more tickets issued on any account after that time.

When half an hour has elapsed the ticket-office will be closed and the gates opened and all strangers excluded; the time-keepers will see this done.

(7) In the morning and after each meal hour, when the bell has ceased ringing, strangers seeking jobs will be admitted inside the gate, and the foremen will make up, as far as possible, broken or incomplete squads by engaging strangers at the following rates for three hours' work:

	s.	d.
Riveters	2	6
Holders-up and iron-workers' helpers	1	6
Rivet and hobby boys	0	9
Strikers	1	6
Laborers	1	0

Any worker refusing to make up his squad in this way and enable the work to proceed will be liable to be dismissed at once.

The time-keeper will take the names of strangers being taken on for temporary purposes, and charge the above sums against the squads they are assisting. When this is done these men will be allowed to pass down the yard. For no other purpose will strangers be admitted, and any employé taking a stranger into the yard without permission from the office or the manager shall be fined 1*s*. People bringing meals are excepted.

(8) Any workers discharged during working-hours, or having to stop on account of rain, or from any other cause, must hand their tickets in at the ticket-offices, or, if they are closed, to the gateman as they pass out, stating the ship they are working at. Anyone neglecting this rule will be fined 1*s*. Such workmen and all men requiring to leave the yard during working-hours on the firm's business must present to the gateman a line from the foreman.

Workmen on being discharged must present to the pay-clerk a line of clearance from the foreman or storeman, certifying that the tools given out to them have been returned in a satisfactory condition; otherwise their pay will be withheld, and the cost of the said tools shall be deducted.

(10) All rivets delivered out must be accounted for by each set of riveters, either in rivets put in, returned good, or spoiled. All rivets left over must be returned to the store every blind Saturday, or before a squad leaves. Any one failing to observe this rule shall be fined 1*s*.

(11) All service bolts and nuts are to be returned to the store before new bolts and nuts are given out for other jobs.

(12) All piece-work will be measured or counted up to the score off time, and no allowance will be given on any account for work completed after that time.

(13) On all piece or contract work 5 to 10 per cent. may be retained from the amount done each day until the whole contract has been completed.

(14) Employés who have received lamps, bears, or ratchets, or such like tools from the stores, must return them each blind Saturday to have them checked. Any one neglecting this rule shall be fined 6*d*. for each offense.

(15) Any employé going out of or coming into the yard by any other way than the workmen's entrance or gate-house shall be fined 1*s*.

(16) Any employé found in the yard or on board any vessel, without permission, fifteen minutes after the bell has rung for leaving off work for the day shall be fined 1*s*.

(17) Boys under 16 years of age on first receiving a ticket must deposit a certificate of their birth with the time-keeper, and present themselves on the following Thursday to be examined by the surgeon. Any one neglecting this rule will be fined 6*d*.

(18) Workmen, apprentices, and boys who are persistently irregular in their attendance shall be dismissed.

(19) Any one committing a nuisance in any part of the yard or on board of any of the ships instead of using the latrines and urinals provided shall be fined 1*s*.

(20) Seven minutes are allowed in the latrines, and smoking is strictly prohibited. Any one infringing this rule will be fined 1*s*.

(21) Any one smoking during working hours shall be fined 1*s*.

(22) Smoking during meal hours will be allowed in the iron sheds, smitheries, and finishing-shops, and in the open yard where there is no light wood-work, but any one found smoking in the joiner-shops, boat-sheds, spar-shed, saw-mill, wood-racks, stores, paint-shops, or in the cabins of ships lying in the river, or other parts where there is light wood-work, shall be fined 2*s*. and render himself liable to be dismissed.

(23) During meal hours no men or boys are to be on board vessels on the stocks, or down about the water side. They must remain in the upper portion of the yard. Any one breaking this rule will be fined 1*s*.

(24) In wet weather, or when men have finished their jobs, they may stand about the furnaces; but any men or boys found there or in any part of the yard after they have been distinctly told to leave by their foreman or the manager shall be fined 2*s*. 6*d*.

(25) Overtime will be paid only after the regular number of working-hours for the day involved have been completed. For instance, no overtime will be paid to a worker not beginning work till breakfast time, until he has made up the time lost before breakfast time.

(26) Employés leaving their employment during the currency of a fortnight will receive their wages on the first pay-day, but if they are dismissed they will receive their money at the time of dismissal, unless they are suspended for a breach of these rules.

All errors of pay must be rectified on or before the Monday following the pay-day, after which no complaints will be received.

(27) All workmen sent to Greenock or Gareloch will get 1*s*. per day, and apprentices 6*d*. extra, and they will find themselves in food and everything except railway fares. The time during which they are traveling, until their arrival at Glasgow station, as well as the time during which they are working, will count as overtime, being paid after the usual working-hours.

28. All Lancefield men working in the yard shall conform to the yard rules. The workmen of other employers shall pass through the gate-house each time they enter the yard and shall have their names taken down by the gateman. They must conform to the rules of the yard and give their names when required to do so by any of the firm's foremen or officials.

29. Employes must show their tickets on being requested to do so by any of the firm's foremen or officials.

II.—Against Accidents.

30. Any person found the worse for liquor, or taking liquor into the yard or vessels, shall be instantly expelled and fined 2*s*. 6*d*.

31. Any workman, who, after having served himself, leaves staging, ladders, gangways, or fastenings of any kind, in an unsafe condition for those coming after him shall be fined 2*s*.; and he is required to report to his foreman any defects through wear and tear, or from other causes, that he may have observed, and which might lead to an accident.

32. Any one carelessly handling materials, or throwing them down without giving proper warning, or neglecting to close hatches or holes after him, will be fined 3*s*. All rubbish and cuttings taken from the deck of vessels are to be passed down a chute.

33. Any person leaving a wood-working machine running, or attempting to clean any machine while it is in motion, shall be fined 1*s*.

34. Naphtha lamps may be used in places where the floor is of iron, or where a wood deck is laid, provided there are no cants or bulkheads fitted or loose wood lying about, and provided a barrel of sand is close at hand. Each lamp must have a proper screwed plug and a strong suspender. Any one using a lamp where there is joiner's wood, or other loose wood, shall be fined 1*s*. No naphtha lamp is to be left in any confined place in case of an explosion.

(35) Any one in the joiner's shop striking matches or using a naked light shall be fined 1*s*.

(36) In cases of accident wounded persons are to be lifted only by members of the Ambulance Corps, if these are available, and the stretcher is always to be used.

III.—Against waste.

(37) Any one taking without special permission of his foreman, a piece of new deck-plank, batten, or other wood and converting it into a shore, thort, or other yard implement will be fined 1*s*. If the wood is spoiled for the purpose it was intended for, he will be charged the cost of the wood at the saw-mill rates, viz:

	Per cubic foot. *s.*	*d.*
Teak	7	0
Mahogany	8	0
Yellow pine	3	3
Pitch pine	2	3

Or at other current rates.

(38) Any worker found destroying wood or any other material or damaging plant or buildings, or carelessly breaking hammer-shafts, or wasting coals, paint, oils, naphtha, or other material, or carelessly burning rivets, or leaving them on the ground or staging, shall have the cost of such wasted property deducted from his wages, or shall be fined 2*s*.

(39) Any worker knocking the heads off service-bolts to save unscrewing the nuts, or cutting a shore to save him from looking for one of proper length, or, without his foreman's permission, cutting ribbands, thorts, or other yard implements, or by carelessness allowing ropes to be chafed, shall be fined 2*s*.

(40) Any one allowing gas, candles, or naphtha to burn, or water to run uselessly, or who needlessly destroys painted work or polished wood-work, shall be fined 2*s*.

(41) Any one using a machine-tool for heavier work than it is intended for, or driving it too fast, or neglecting to work it properly, shall be fined 2*s*. If the machine-tool breaks down he may be held liable for the damage done.

(42) Any rivet boy or other person leaving behind him red-hot tongs, rivets, or coals, or any burning material, or leaving fires above a wood deck without trays placed below them, shall be fined 2*s*. and may be held liable for damage.

IV.—Against dishonesty.

(43) Any time-worker found jobbing for himself, or giving assistance to piece-workers, or idling his time, or leaving off work to be at the gate when the bell rings, or taking an unnecessary time to get to his work after receiving his ticket, shall be fined 2*s*., and may be instantly dismissed.

(44) Any workman putting in a time-ticket after he has started working on piece shall be fined 2*s*.

(45) Any employé attempting to defraud the firm, either on their own account or for others, through the time-keeping system, or to cheat the piece-work clerks, shall be find 2*s*. 6*d*.

(46) Any workman found to be dishonest toward his coworkers may be turned out of the squad or have his contract broken.

(47) Any workman breaking open another workman's box, or taking tools from him, shall be fined 2*s*. 6*d*.

(48) Employés found taking pieces of wood or chips out of the yard, without an order, will be charged for the wood at the saw-mill rates; or for this offense, as well as for all more serious thefts, they may be handed over to the police. Any suspected person will be made to stand aside until the other men have passed out.

APPRENTICES.

In British engineering concerns of late years two classes of apprentices have been taken. The one is composed of those who are too poor to pay for instruction, and who often have no purpose of rising higher than mechanics; the other is made up of wealthy men's sons who wish to gain a knowledge of the business. The former usually receive nothing for their first year and are then gradually raised. The "gentleman apprentice," as he is called, pays from 200 to 300 guineas for five years' instruction, and enjoys great privileges.

In Her Majesty's dock-yards, boys to be apprenticed as shipwrights and fitters are entered through competitive examinations. The applicant must be between 14 and 15 years of age, and he must satisfy the superintendent of the yard of his age, good character, and physical fitness. He must also be a child of a British subject. The examination comprises arithmetic, geography, handwriting, grammar, English composition, the first three books of Euclid and Algebra up to and including quadratics. Those having the necessary qualifications are bound by indentures to serve seven years. During the first year they are paid 3*s.* per week; this increases 2*s.* per week each year, until in the seventh year it amounts to 15*s.* per week.

After five years spent in the dock-yard, a limited number of the apprentices are sent to the Royal Naval College, at Greenwich, for three sessions, spending the vacations at the dock-yards. After this course is concluded they return to the yards and are given positions as supernumerary draughtsmen, or they may be sent to sea for one year in Her Majesty's ships, to return to the dock-yard duties as stated above. Such graduates of the Naval College may pass through the different grades of assistant constructors in accordance with the regulations of the Royal Corps of Naval Constructors, which I append:

A corps of ship-building officers having been established by Her Majesty's order in council of the 23d of August, 1883, the following instructions are issued for the guidance of those concerned:

(1) The number, designation, and salaries of the members of the corps will be as follows:

ADMIRALTY.

Director of naval construction, £1,500 per year, rising to £1,800 after five years' service.

Surveyor of dock-yards and chief constructor, £600 a year; duty pay of £100 per year for acting for director of naval construction, and a London al nce of £150 a year.

Two chief constructors, £600 a year, rising to £850 by £25 a year, and a London allowance of £150 a year.

Three constructors, £400 a year, rising to £550 by £20 a year, and a London allowance of £120 a year.

Five assistant constructors, first class, £300 per year, rising to £450 by £15 per year. Duty pay of £50 per year to assistant constructor in charge of foreign records. Duty pay of £50 a year to assistant constructor acting for chief constructor.

One assistant constructor, first class (for scientific experiments), £250 a year, rising to £300 by £15 a year.

Six assistant constructors, second class, £160 a year, rising to £240 by £10 a year, and a London allowance of £50 a year.

DOCK-YARDS.

Three chief constructors, Chatham, Portsmouth, and Devonport dock-yards, £700 ear, rising to £850 by £25 a year, and a house.
Three chief constructors, Sheerness, Pembroke, and Malta dock-yards, £600 a year, ing to £700 by £25 a year, and a house.
Eight constructors, £400 a year, rising to £550 by £20 a year, and a house.
One constructor, Hong-Kong, £400 a year, rising to £550 a year; a house or an al- wance of £150 a year in lieu thereof; and a colonial allowance of £100 a year.
One constructor, Bermuda, £400 a year, rising to £550 by £20 a year, a house and olonial allowance of £100 per year.
Ten assistant constructors, first class, £250 a year, rising to £300 by £15 a year.
Eighteen assistant constructors, second class, £160 a year, rising to £240 by £10 a ar.
Nine assistant constructors, third class, £110 a year, rising to £150 by £10 per year.

DUTIES.

(2) The corps of naval constructors will be under the controller of the navy.
(3) The director of naval construction will be the head of the corps, and will per- rm such duties as may be assigned to him from time to time by the Admiralty.
(4) Chief constructors and constructors will be intrusted with the designing, build- g, fitting, and repairing of ships for Her Majesty's service.
(5) Assistant constructors of the first class will be employed in the office of the ntroller of the navy, in preparing designs and specifications of the ships to be ilt or refitted, or on such other duties as may be assigned to them by the controller. the dock-yards they will take charge of the drawing offices, conduct special expe- ental investigations, act as foremen of the yard when selected for that office, and employed as overseers of works in progress at contractors' premises.
(6) Assistant constructors of the second class will be employed in the office of the ntroller of the navy to assist in the preparation of plans and specifications, as erseers or assistant overseers of works in progress at contractor's premises, as pro- sional secretaries to the chief constructors at the home dock-yards, in the supervis- of the record of weights of materials worked into ships in process of construc- n, in the preparation of return of weights carried, and other estimates of the ught and trim of ships, and in giving such assistance to the superior officers of the ps as may be directed by the controller of the navy or by the superintendents of the k-yards to which they may be attached.
(7) Assistant constructors of the third class will be employed in the dock-yards in- supervision of the weights of materials worked into ships in the process of con- uction, in the preparation of returns of weights carried and other estimates of the ught and trim of ships, and in giving such assistance to the superior officers of the ps as may be directed by the controller of the navy, or the superintendents of the k-yards to which they may be attached.

ENTRY AND TRAINING.

(8) Studentships in naval construction, not exceeding three in number in any one ar, will be offered to public competition at the annual examination for engineer udentships in Her Majesty's dock-yards, the limits of age, subjects of examination, d other conditions being those prescribed from time to time for such studentships. e studentships in naval construction will be offered to the successful candidates at e examination in the order of merit.
(9) The candidates who receive appointments as students in naval construction ll reside for a term of six years at Portsmouth in the Training-School for Engineer udents, and be subject to the same conditions as to fees, pay, uniform, and other

details as may be prescribed from time to time for engineer students. Their co
of instruction will be laid down from time to time.

(10) With a view to obtain candidates from the existing source of supply, con
rently with those entered by public competition, the following regulation wil
adopted for the training of shipwrights' apprentices in the dock-yards:

(*a*) The limits of age for the entry of apprentices will be from 14 to 16 years.

(*b*) A limited number of apprentices who pass the best examination at the en
their third year, and are recommended for conduct, will be permitted to attend sc
for another year.

A like rule will apply to the examination of apprentices at the end of the fo
year.

(*c*) After the examination at the end of the fifth year, apprentices who pa
highly creditable examination, and are recommended for conduct, will be eligibl
transfer to the training-school. The number to be admitted to the school wil
fixed annually by the Board of Admiralty in accordance with the requirements o
service.

(*d*) To meet the expenses attendant upon admission to the training-school
selected apprentices will receive studentships of the value of £25 each, tenabl
one year.

(11) Students in naval construction, on passing satisfactorily from the trai
school, will be admitted to the Royal Naval College at Greenwich, on probatio
one year, at the expiration of which period a report of their progress will be ma
the admiralty. Should the report be unsatisfactory the students will be dischi
from the service, or sent back to the dock-yards as apprentices, as the case may

(12) The engineer student who stands first in the final examination held ann
in the training-schools for engineer students, will, if recommended by the direc
studies, be allowed the option of admission to the Royal Naval College as a st
of naval construction.

(13) While at college, students in naval construction will be required to w
suitable uniform.

(14) Bonds: On entry a student will be required to join with his parents or g
ians in a bond of £300 to enter the service as an assistant constructor if his ser
are required.

(15) An assistant constructor will not be permitted to leave the service until
years have expired after the completion of his term at the Royal Naval Col
unless he shall pay the sum of £300 if entered as a student from the apprentice
or the sum of £500 if entered by competition. This payment is for the purpo
defraying the charges incurred by the public for his education.

(16) Liability to foreign and sea service: Every student entering the royal
of naval constructors will be liable to serve at any foreign naval establishmen
admiralty may direct; he will also have to proceed to sea if so required.

PROMOTION.

(17) Such students as obtain first and second class professional certificates on
final examination at the Royal Naval College will be admitted to the corps
students who obtain first-class certificates will be appointed second-class assi
constructors, and the students who obtain second-class certificates will be appo
third-class assistant constructors. Students who obtain third-class certificates
not be admitted to the corps, but will receive, as heretofore, appointments as draw
men in the dock-yards.

(18) Foremen of the yard eligible to the corps: Any foreman of the yard whos
does not exceed 50 years, and who is specially recommended by his superior of
may be admitted to the corps of second-class assistant naval constructors, pro
he passes a qualifying examination in the elements of ship design and the calcul
connected therewith.

9) Foremen so transferred will have all the superior appointments in the corps to them.

s admission to the corps foremen will retain their existing scale of salary so long ey remain in the grade of assistant constructor of the second class.

0) Candidates from outside the service: A limited number of candidates under ears of age, who can furnish evidence of character and of thorough training in tical ship-building, will be permitted to attend the annual examination held at Royal Naval College at the conclusion of each session. Should these candidates eed in obtaining first or second class professional certificates they will be offered intments as assistant constructors of the class to which their certificates would tle them.

1) Assistant constructors of the third class will serve for five years in that grade re being eligible for promotion, and such promotion will be by seniority as vacan- occur, provided that the officer is favorably reported for character, ability, and stry.

2) Assistant constructors, on promotion to the second class, will generally be em- ed for a time in the department of the controller of the navy.

3) Promotion from the second to the first class will be by selection. Assistant tructors who obtain first-class certificates will be eligible for promotion after five s' service after the date of leaving the Royal Naval College, and those who obtain nd-class certificates will be eligible after seven years of such service.

4) Vacancies in the grade of constructor will be filled by selection from the as- ant constructors of the first class.

5) Vacancies in the grade of chief constructor will be filled by selection from the tructors.

6) In making selections for advancement in all grades of the corps the admiralty be guided solely by the consideration of special fitness for the vacant appoint- ts. To mark this unmistakably the names of the gentlemen belonging to the s will be arranged in alphabetical order in their respective classes.

7) Annual reports on the assistant constructors will be made by the chief con- ctors of the yards and forwarded by the superintendents to the admiralty. These rts should mention the large or principal works upon which the assistant has n employed during the year.

RETIREMENT.

8.) The present regulation as to compulsory retirement at the age of sixty years remain in force.

DMIRALTY, *November* 19, 1883.

Before proceeding to give a detailed description of the course of in- tion for students of naval architecture at Greenwich, it may be resting to take a brief glance at the history of naval education in eral.

chools for naval officers had their origin in France, about the year 0, nearly one hundred years in advance of the Royal Naval Acad- , which was established at Portsmouth, England, in 1729. The nch Government gave much encouragement to its naval schools, lting in a steady advancement toward perfection of the science of -building and the art of naval architecture; mathematicians and ntific men of great ability were induced to give their attention to important subject, and the subsequent publication of M. Bouguer's ite du Navire, and of the works of the no less renowned authors, nard Euler, Juan d'Ulloa, and Chapman, formed the substantial dation upon which the modern science of ship-building has been ted.

uring all this time scientific investigation and the study of the

principles of ship construction had, apparently, been at a standstill in England; but in 1811 a new impulse was given to the movement by the formation of the School of Naval Architecture, at Portsmouth, under the management of Professor Inman, of Cambridge University, to whom England is indebted for the translation of several valuable works, among them Chapman's Architectura Navalis Mercatoria. This school was, however, not a success, owing, no doubt, to the opposition it experienced from both naval officers and ship-builders, who disliked any methods which tended to prove their education defective. It was abolished in 1832, and seven years later the Royal Naval Academy suffered the same fate, because of the imperfections of the system of appointments, which did not require the candidate to be a graduate of the academy. The Naval Academy was succeeded by the Royal Naval College, founded at Portsmouth in 1839. The School of Naval Architecture was re-established in 1848, only to be closed in 1853. But in 1864 it was reopened under a much improved organization, and continued in operation at South Kensington until 1873, when it was consolidated with the Royal Naval College, which was transferred to Greenwich in October of that year, and is at the present day devoted to the education of officers for all branches of the service.

In the United States the attention of Congress was called to the necessity of establishing a school for the education of officers for the Navy as early as 1800; but it was not until the administration of President James K. Polk, in 1845, that the Naval School was formed at Annapolis, in the State of Maryland. In 1849 it was reorganized, the course of studies was revised, and the name of the institution changed to the "United States Naval Academy." The course of studies was again reconstructed in 1865; and although several changes have since been made in the laws regulating admissions, there have been no material alterations in the system of instruction which was then arranged.

The following account of the course pursued by the students of naval construction at Greenwich is interesting:

COURSE FOR NAVAL ARCHITECTS AT GREENWICH.

The course of instruction in naval architecture in the Royal Naval College is arranged to be finished in three years. Each year constitutes a session of nine months. Christmas and Easter divide the session into about three equal terms. Intermediate examinations are held at these times to test progress, after which holidays of two weeks are granted to the students. All examinations for graduation, &c., are held in June, and are designated final examinations.

The method of instruction consists of a series of lectures on each subject, at which the students take notes. In the more difficult subjects, as mathematics and mechanics, not all the time is devoted to lectures, but the greater part is used in giving individual instruction, the professor and his assistants remaining in the class-room to answer questions and explain parts of the lectures. There are seven hours a day of class-room instruction, four in the morning, from 9 till 1 o'clock, and three in the afternoon, from 2 till 5.

The morning is devoted to mathematics and mechanics, and also to lectures in physics and chemistry. There are three mornings of three hours each for mathematics and three for mechanics. The morning hour of each morning is given to lectures in physics and chemistry.

The studies of the course are grouped in two classes, called theoretical and practical. The theoretical branches consist of pure and applied mathematics, applied mechanics, propulsion and resistance of ships and theory of waves, and stability and oscillation of ships. The practical branches include all the professional work, some *subjects in* applied mechanics, and practical and theoretical physics and chemistry.

The course in mathematics is equal to the highest university course in England, and is under the special charge of Professor Miller, M. A. In the first year the elementary pure mathematics are finished, including a rapid review of geometry, algebra, trigonometry, and conic sections. To the differential and integral calculus more time and care are devoted, especially the former. A short course in descriptive and modern geometry is given the first year, but it is not included in the final examination for graduation. In applied mathematics the first year's course includes analytical statics, kinematics, kinetics, and some portions of dynamics of a particle and hydrostatics. The second year's work alternates as to subjects, as the second and third year students take their instruction together. It includes either solid geometry or differential calculus in pure mathematics; and hydrostatics and hydrodynamics, or spherical dynamics, in applied mathematics. One-third of the second year's work consists of a few minor special subjects, such as higher conic sections, including abridged notation and trilinear co-ordinates, determinants, theory of equations, and a few unfinished parts of the differential calculus. These subjects are given the latter part of the session, while the third-year students are passing for their graduation.

Todhunter's mathematical series are used, partly for reference and partly for study, many of the methods being replaced by the professor's notes. Professor Miller adopts with his students a system of asking questions, and draws from them all their knowledge upon any subject before explaining it in his lecture.

The applied mechanics is by far the most important department of the theoretical and scientific studies. In the first year the course consists of calculations of stresses in structures, the graphic representation of shearing forces and bending moments, the theory of virtual velocities as applied to machines for the construction of curves of velocities or efforts, strength of materials, theory of steam and the steam-engine, heat and combustion, and an elementary course in hydraulics. The second year's work includes hydraulics, deflection of beams, graphic statics, and an elementary course in trochoidal waves. The last year is devoted to strength of materials, the resistance and propulsion of ships, including the stream-line theory of resistance, and theory of waves. All work in this department is under the supervision of Professor Cotterill, M. A., F. R. S., the author of several valuable works. He has been known, since the death of Professor Rankine, as the highest authority in England upon applied mechanics. His lectures, and the questions which accompany them, show with what care the course is arranged so as to be thoroughly applicable to questions arising in practice. This department, therefore, forms the important step for making scientific knowledge useful to the practical mind. In the first year's work Professor Cotterill avoids all use of the higher mathematics, and the course could be taken with advantage by any one who had but a fair knowledge of algebra, geometry, and trigonometry. In the other years, however, applications of the integral calculus and of differential equations are necessary. Mr. Hearson, chief engineer, R. N., is the assistant in this department, and conducts all the lectures of the second-year students.

The students in naval architecture attend the general lectures in physics and chemistry given at the college. Besides these lectures there is a three-years course in practical chemistry on qualitative analysis, and a two-years course in practical physics. The latter includes the determination of the specific gravities of various substances, the moduli of elasticity of metals, moments of magnets, resistance of batteries and circuits, and work upon light and heat. The physical and chemical laboratories are very extensive, and all the apparatus is of the first class.

Two or three afternoons a week are devoted to the professional work. In the first year the course includes ship calculations and laying off. Each student performs very carefully the following operations:

Proofs and applications of the rules for finding the areas and positions of the centres of gravity of plane curves, including Simpson's rules, the method of polar co-ordinates, and the graphic method.

Proofs and applications of rules for calculating the displacement and center of buoy-

ancy of ships, including the double application of Simpson's rules to the usual form of displacement sheet; the same for radial or polar co-ordinates.

Construction of curves of displacement and tons per inch of immersion, and their use

Determination of the position of metacenters for longitudinal and transverse inclinations.

Construction of metacentric positions for various draughts, or the metacentric diagram.

Graphic representation of the distribution of buoyancy, and weight and determination of the curves of loads, shearing force and bending moments in still water.

The design of a midship section of a merchant ship under Lloyd's rules, to give practical ideas of scantlings, &c., of the various parts, or a midship section of a war vessel showing the same.

The laying off of the stern framing of a wooden ship, showing the distribution of the timbers and their butts, and the determination of the bevelings of the cants and double cants, or the laying off of the stern of a steel ship, showing the arrangement of the frames, &c.

The graphic methods are used as checks, and all calculations have, if possible, duplicate methods. For some of these calculations the students are arranged in twos, so that they may cause mutual checks upon each other's work.

At the close of the first year's course the students may be said to be familiar with the ordinary ship calculations.

For the first three months of the second year the time usually devoted to the applied mechanics in the morning is taken up in the calculation of stability, besides the usual time in the afternoon. This work includes calculations of statical stability and construction of curves of stability, the determination of the dynamical stability by the integration of the former or by Moseley's formula. In this work an actual ship or a feasible design is used, and the calculations consist in making complete curves of at least three conditions of the ship: (1) Curve of statical stability when the ship is intact; (2) curve of statical stability with the ship intact, in the light condition (when all the consumable stores are removed, and there is no water in the boilers or coal in the bunkers); (3) curve of statical stability when the vulnerable parts of the ship are riddled. Not only are the curves constructed for the usual range, but by the applications of a few simple principles of mechanics the curve of stability for the complete turning of the ship is worked out. This involves a large amount of labor, but is carried out in full, that the student may have a practical knowledge of the methods of determining this important feature of a ship.

Beside these computations, the loci of the center of buoyancy, metacenter, surface of flotation, and polar curve of stability are constructed for the same ship; and these same curves are constructed for simple sections of various draughts, beams, and reserves of buoyancy, to show the effect of these upon stability.

The remainder of the second year is taken up in design work. The students are arranged in twos, each two taking up and completing a design. The selection of the type of the design is left entirely to the discretion of the students themselves. The design includes the preparation of the drawings of the ship and the calculation of its important qualities. With some assumed type the displacement is taken as the basis of the work, and the process of designing may be briefly summarized:

Preliminary estimate of the dimensions to fulfill conditions as to draught, trim, armor, armament, speed, and equipment, as well as to provide sufficient stability.

Preparation of sheer drawing, midship section, and plans of decks, holds, and flats; specification of scantlings, preliminary to the determination of weights, &c.

Calculation of the center of buoyancy and metacentric height. When this stage is reached detailed calculations follow as to the weights of hull, armor, armament, equipment, &c., and the estimation of the center of gravity.

This marks the stage when the finished vessel, as to dimensions, may be completely determined to fulfill the required conditions as to trim, stability, &c., and completes *the preliminary* work.

Preparation of an outline profile and plans of decks and hold, showing the main features of stowage throughout the ship; preparation of sail plan and calculation of the center of effort and tendency to stand up under canvas.

Calculation for and construction of displacement curves, tons per inch of immersion, &c.

Calculation of stability in intact condition, both fully equipped and light, also in the riddled condition; calculation of the metacentric diagram.

Calculation of speed under steam.

Calculation of longitudinal curves of weights, loads, shearing forces, and bending moments of ship in still water.

Calculation of equivalent girder and estimate of the stress upon the structure at the points of greatest strain both in the hollow and on the crest of wave.

This includes all the practical design work. During the progress of this work occasional lectures are given in methods of designing and comparing data from actual ships given. During the last year a course of lectures is given in stability and the oscillations of ships. These lectures may be included under the heads of statical stability, dynamical stability, and oscillations. The first includes:

General theorem of Dupin and application to ships.

Metacentric methods of estimating the initial stability of ships, metacentric heights for various classes of ships, with results as to amount of stiffness desirable.

Applications of metacentric method, including experiments to determine the center of gravity of ships, variations of stability due to additions or removal of weights. Estimates for change of trim due to shifting weights or adding or removing weights; efficiency of water-tight subdivision in preserving the stability when compartments are bilged. Stability of ships aground and partially waterborne, &c.

Stability at finite angles of inclination, with details of various methods by Attwood, Reed, and Barnes. Construction of curves and examples of form of such curves for typical ships. Influence of draught, freeboard, beam and vertical position of center of gravity upon stability.

The second may be said to include Moseley's formula and other expressions of dynamical stability by direct calculation or from curves. Connection of dynamical stability with safety of ships when struck by sudden gusts of wind. Review of dynamical stability.

The third includes unresisted rolling in still water, with effect of resistance; experiment of still-water rolling. Construction of curves of extinction and their qualities. Oscillations among waves, with Froude's latest experiments. Deductions from theory of rolling and observations of particular ships, pitching, heaving, yawing.

This department is under Mr. William E. Smith, assistant constructor of the controller of the admiralty, and his assistant, Mr. Cotwell. These instructors are always present at all the practical work and ready to give instruction, information, or answer questions. Mr. Smith gives all the necessary lectures on the professional subjects, including those of stability, oscillations, &c.

Each year there is a course of five lectures in practical ship-building, practical engineering, and some general theoretical subject, such as steering of ships, stability, &c. These lectures are not special, but are given to all the officers at the college, and so are not so important to the students in naval architecture, though they are required to attend them.

Professional certificates are given to graduates at the end of three years showing their proficiency in the subjects of the course as determined by the examinations. There are three grades of professional certificates—first, second, and third; the first requires 75 per cent. of the aggregate marks; the second, at least 50 per cent. in the practical subjects and 50 per cent. in the theoretical subjects; and the third, 50 per cent. of the aggregate marks, but not 50 per cent. in both groups. The examinations include about twenty papers in all, and three hours are allowed for each examination. All examinations are set by professors not connected with the college; those in math-

ematics and mechanics being usually under the charge of a Cambridge profe those in architecture, practical calculation, &c., under Director of Naval Cons tion Barnaby. Each student has assigned to him an index number, which he us all examinations instead of his name.

Two sets of examination papers are given at the annual examination for the dents of the first year, and marked A2, and one for the third-year, or graduating dents, marked A. The second-year students take the papers made out for the g nates, although they have not finished all the work included in the papers.

The following is a list of the subjects and the marks assigned to each:

	M
Practical group.	
Physics (two papers)	
Practical physics	
Chemistry (two papers)	
Practical chemistry	
Heat, steam, and combustion	
Steam and steam engine	
Strength of materials	
Practical ship-building	
Ship design and calculation	
Design of ship	
Aggregate of practical group	4
Theoretical group.	
Pure mathematics (two papers)	1
Applied mathematics (two papers)	1
Applied mechanics (two papers)	
Stability and oscillations	
Propulsion and resistance of ships and theory of waves	
Aggregate of theoretical group	5
Total aggregate	10

In order that the foregoing may be compared with the system pursu in France, I add a short description of the course for naval archite in the École Polytechnique.

THE FRENCH SCHOOL OF NAVAL ARCHITECTURE.

The course of French Government students of naval architecture occupies four ye The first two are spent at the École Polytechnique, where all French Government gineers receive their theoretical education; and the last two years at the School Application of Marine Engineers. The latter course is divided into two parts of a y each: The first year being devoted to designing marine engines, and the last to s design and calculation.

Free students, "ètives libres," are allowed to attend the course of instruction the School of Application, and on entering the school are required to pass an exa nation. This covers part of the course of instruction in the same branches at t École Polytechnique, but it represents the knowledge a student absolutely requires the School of Application. In regard to the work of the Government students dur vacation, the first two summers are spent on leave at their homes; the last two spent at the dock-yards.

For the last two years foreign students have been allowed to work in the Gove ment dock-yards, under the same conditions as French students, during their atte ance at the School of Application. The only serious disadvantage that foreign stude are under is that all their ship and engine designing is done at their homes and not the drawing-rooms. Their work, however, is corrected by the instructors, but can under the rules, be as beneficial as the system adopted in the British dock-yards.

ON AND STEEL WORKS, STEEL CASTINGS, AND ARMOR-PLATES

The manufacture of iron and steel is so closely related to modern val architecture that, without diverting seriously from the primary jects of my tour, I felt it important to visit such works as were con- nient to my several centers of observation and were of sufficient te to warrant time spent in their inspection.

The Steel Company of Scotland is one of the largest establishments, d has two distinct works: those at Blochearn, in Glasgow, and those Newton, in close proximity to that city. Both are great in their ea and plant. The Blochearn works are the more recent and are ex- llently equipped for turning out vast quantities of Siemens steel, incipally in the shape of plates. The origin of the company dates om the first manufacture of Siemens steel commercially, as the works ere started immediately after the successful trials of the furnaces con- ructed by Rowan, of Glasgow, for the Tharsis Copper Company.

In 1868 the Landore Siemens Steel Company, limited, was formed, d may be regarded as the representative concern of England and ales. From a recent publication I abstract the following description:

The Landore-Siemens Steel Company possesses two distinct works, known as the old" and "new works," respectively. The former occupy about 5½ acres, three es of which are covered by buildings. The new works are much more extensive. ey are on the banks of the River Tawy, an orange-colored stream, which is navi- ble for small craft as far as the works. The latter covers an area of 94 acres, 9 es of which are covered with mills and shops, and are intersected by about 7 miles railway lines. When in full work about 1,500 men are employed. The company at present busy with a number of important contracts, and the works were in tty general operation on the occasion of my visit. The Landore offices of the pany are in a block of buildings at the old works, and after this date, I am in- med, the clerical and commercial departments, hitherto carried on at No. 3 West- ster Chambers, will be transferred to Landore.

Having made the acquaintance of Mr. F. J. Carrulla, the courteous general man- r of the company, I was first conducted over the new works, which, as already ed, are the more important of the two. In the melting-house, which is a most quately-equipped building, the fuel, in the shape of gas, is produced in a series of producers, which are situated in close proximity to the melting-furnaces. The gas nade in the ordinary method from the best bituminous slack, and is conducted to lines of melting-furnaces situated opposite the gas producers, and also to all er parts of the works, by means of large pipes. There are sixteen 8½-ton Siemens ri-hearth furnaces in this department, and these are capable of turning out 1,500 s of steel ingots per week. In the course of manufacturing the steel each furnace harged with about 8½ tons of pig-iron and scrap, of which the pig is supplied from company's own furnaces and from Cumberland. In the case of the company's brand, Swedish pig iron, mixed with other qualities, is used. The furnace being rged and heated the metal becomes melted and at a good heat in from four to five rs' time. At this stage iron ore, broken in pieces about the size of ordinary road al, is thrown in, from 25 to 30 cwt. being the usual proportion for an 8-ton rge. When introduced the iron-ore has the effect of making the molten metal violently, with the result that the latter becomes decarbonized and is left in the dition of almost pure iron. Successive additions of ore are made at intervals. en the iron has become nearly soft enough it is allowed to stand for a time, so that iron may work well out of the slag, to assist which operation a small quantity of ken limestone is added periodically.

proper degree of softness having been obtained, certain proportions of ferro- nese and spiegel are added, the quantity introduced determining the quality of

the steel. When these last-named ingredients have been incorporated with th
the furnace is tapped, and the molten steel allowed to run into the ladles, and
into ingot molds, which lie in the pit of the melting shop in convenient pr
to each furnace. Of the metal contained in the ore fed into the furnaces, ab
half passes into the steel; so that, as the carbon and silicon present in t
amounts to 8 per cent., the yield of ingots and scrap together is within abou
cent. of the pig-iron and spiegel put in. I may mention here that after the fl
of metal is reduced to the lowest point of carbonization, the heat of the furn
be maintained in such a state for a sufficient time to allow of samples to be t
and tested. This is one of the special advantages of the Siemens process; t
tions of either pig or scrap may be made to the bath to bring it to the desired
This having been determined, the requisite proportions of ferro-manganese a
geleisen may be added in a solid condition, and the result is a bath of fluid
whose chemical condition the exact character is known. The spiegeleisen a
manganese naturally improve the character of the steel, the latter not merely
as was at one time supposed, as a purifying agent, but being calculated to
act the influence of impurities. The melting shop is conveniently arranged
on each side a longitudinal series of producers, opposite which, and running
to them, are the steel furnaces. The pit runs the entire length of the cente
shop, and is traversed longitudinally by a crane running on rails. The in
hoisted out of the pit by means of the cranes, which command the entire l
The shafting which works the cranes is square, except, of course, at the h
The latter are supported on tumbler brackets, which fall forward to allow t
to pass over.

On the way from the melting-shop to the hammer department I noticed on
mens's rotating furnaces, by the employment of which iron blooms are manu
from the ore direct, instead of intermediate pig-iron. The product is very p
is melted up into steel in the melting-furnaces after a similar fashion to that
described. The hammer-shop and the mills are situated at some little dista
and on a higher level than the melting-houses. The ingots of steel, placed u
trucks in the melting-shop, are taken to the hammer-shop. The ingots are h
mitted to the hammers, of which there are six, five being 8-ton hammers,
being of 5 tons, all of Thwaite & Carbutt's make, and are converted into v
shaped billets and blooms. In this department there are several series of
furnaces for heating ingots before they go to the hammer, and the blooms an
preparatory to their going to the rolling-mills. The fires, like the furnaces, ar
by gas; in fact, everything requiring heat is heated by gas, excepting the
boilers, which are fueled with coal.

The mill department is equipped in a very complete manner. It contains on
mill, with 7-foot 6-inch rolls, and a 24-inch merchant mill for large bulb tees
and tin-plate bars. These are driven by a pair of Ramsbottom's reversing
gines, with cylinders 34 inches in diameter and 4-foot stroke. There is also a
patent tyre-mill, driven by a pair of vertical engines, 30-inch cylinders an
stroke; also a 16-inch bar-mill for light bars, angles, and tin bars, and a 10-in
mill for wire rods. The two last-named mills are driven by a pair of vertic
engines with 30-inch cylinders and 3-foot stroke. The blooms are taken from t
ing-furnaces in a condition of a high heat, placed on trollies, and conveye
rolls, where they are gripped and compressed, being drawn back again by th
ing action of the mills.

My attention was directed before leaving the mill department to several
machine tools, including a planing machine and a cross-cutting machine f
planing and cross-cutting the edges of armor deck-plates and cutting them into
From this department I was conducted to the rivet-shop, where a double-head
machine, made by Messrs. Marr & Tagell, of Birmingham, was busy producin
and ship rivets. Small furnaces heated by coal are also situated in this shop
used for heating the round bars of steel preparatory to their being introduc
rivet-making machine, which speedily cuts them and transforms the cut port
accurately-formed rivets. In this shop are also some examples of the old-f
type of rivet-making machines, worked by the combined and somewhat h
exertions of a man and a boy. The rivet department turns out an average o
of rivets per week. The Marr & Tagell rivet-machine is driven by a horizont
which works in a corner of the shop. Just outside of this department I
number of bolts, some 24 and others 32 feet long, which formed part of the
which the company have on hand for the new Forth bridge.

On leaving this department I was shown the brick works of the company,
iron foundry, pattern and wagon shops. The company are thus as nearly as
self-sustained. Adjoining is the extensive blast-furnace department, the pr
the Landore-Siemens Company, but worked by the Swansea Blast Furnace C
This branch contains two blast furnaces, one of them 66 feet high and 19 feet
the other 54 feet high and 18 feet bosh. The blast for both is heated by

-Siemens hot-blast stoves, and the two blast engines employed were made by son, of Leeds. They have blowing cylinders 100 inches in diameter and steam inders 40 inches in diameter. The weekly supply of the two furnaces is about 900 s.

The old works of the Landore-Siemens Company were next visited. They are inly devoted to the production of steel boiler and ship plates. In the melting de- rtment there are eight open-hearth steel-melting furnaces of from 9 to 12 tons ca- city, and two more of larger size are at present under construction. In the ham- r department there are two 8-ton hammers and two forging hammers, one of 30 t. and the other of 12 cwt., for making all kinds of steel forgings. In the mill there of course the usual series of heating-furnaces and one 28-inch plate-mill, with 7-foot nch rolls, driven by a pair of Ramsbottom's reversing mill-engines, with 30-inch linders and 4 feet stroke. Here also are several shearing-machines for cutting ates and other necessary machine tools. The various departments are, as at the w works, replete with lifting and transporting arrangements, and the processes are the main practically the same as at the new works, and need not be recapitulated. The testing-machine house was next visited. Here is a most ingenious and mathe- atically accurate machine, by Buckton, of Leeds, for testing the strain-resisting pacities of the steel manufactured. The process is an extremely gradual one and great nicety, and the results of the testing operation performed during my stay eraged so nearly the same as to convince one of the marvelously uniform character the Siemens steel. The steel foundry is well arranged. The steel used is melted Siemens's furnaces, and the products of the foundry include worm-wheels, gears, am hammer tups, and the like.

The price of Siemens steel has of course been affected by the general pression of business. It may be interesting, however, to state that dur- g my stay in England the Admiralty placed contracts for material r the hulls of the ships of the Mersey class, in amounts of 1,200 tons, £7 6*s.* and at £7 11*s.* 6*d.*, delivered at Pembroke and Devonport, re- ectively.

The use of steel castings has lately increased so in the United States t it may be proper only to briefly notice their application abroad. ry excellent cast stems and stern-posts were seen in Glasgow. Rud- r frames and other complicated pieces have been produced of a supe- r quality; while the small fittings about a ship to which steel has n applied are very numerous. Several firms now make a specialty steel castings; among these the Messrs. Hadfield, of Sheffield, have uired a great reputation. Their establishment, known as the Hecla undry, is devoted exclusively to this branch of manufacture; and their ent steel, which derives its properties mainly from a large percent- e of manganese which it contains, is in demand for a great variety of letails, including gear-wheels, sheaves, colliery wheels, hammer-tups, draulic presses, crank-shafts, couplings, wrenches, &c. This patent el contains from 7 to 20 per cent. of manganese, and manifests a wide ge of properties, according to the proportion of manganese present. forms castings of unusual soundness. At the last general meeting of Institution of Mechanical Engineers samples were exhibited, among ich was a test bar, 12 per cent. manganese, which, though hard enough turning iron, had been bent double while cold. It had a tensile ength of 42 tons per inch, with an elongation of 20.85 per cent. Tools le of this material need no hardening or tempering. The effect of ating and quenching is to render it softer. This foundry has capac- for making castings up to 16,000 pounds weight.

While in Sheffield I visited the large armor-plate mills of Sir John own & Co., limited, and Charles Cammell & Co., limited. In the first- ntioned establishment, after observing the Bessemer and hearth pro- ses in detail, I had the pleasure of seeing the manufacture of a plate the Ellis system. The steel and iron plates having been riveted to ther, with an interstice of about 2 inches, a frame of bar-iron hav- been inserted between them to maintain this amount of separation

the combination was raised to a high temperature in a gas furnace. this instance the iron plate was about 10 inches thick, and the about 5, and the period required for the heat was about twenty h At the end of that time the plates were drawn from the furna huge tongs. A traveling crane picked up the future armor-plat carried it to a pit, into which it was lowered and firmly compresse tween two flat plates by hydraulic pressure. The charge of int diate steel was then brought along from the converter in a large p the aid of a locomotive. A distributing trough, having holes i bottom, was arranged across the gap between the two plates, an molten metal poured in. The plate was then allowed to partially I was informed that on the following day this plate would be rolled to about half its thickness, when it would be ready for planing trimming.

The plant of the Atlas Works for effecting these operations is large and doubtless comprises some of the heaviest tools in the dom. Many of these, in particular three massive planers, whic workmen have sportively christened "the three Graces," are by th inent firm of Shanks & Co., of Johnstone; a large number of ship-building tools are illustrated in the photographs which accon this report. In other respects the Atlas Works are also well equi They are supplied with hydraulic power, which, among other thin applied to flanging the heads of marine boilers, the whole flange operated on at once. In this case a large stock of swages and forn kept, which are readily bolted in place upon a horizontal table, corresponding plate above it; between these plates the boiler h pressed, as in dies. As the plate is heated all over in this m flanging, it is evidently of special value in using steel, where dis have so often been attributed to the effects of irregular and rep heating. I saw a number of very large plates operated upon, an flanges were beautifully turned. This company has its own blas naces, collieries, and ore mines. The ore of the district, brown h tite, is not useful in the production of Bessemer pig. Cumberlan are relied upon for that product.

At the Cyclops Works of Messrs. Cammell & Co., which are a great magnitude, similar manufactures were observed, and the for the production of compound armor on the Wilson system w spected. The iron plate, which is to form the base of the arm surrounded on three sides by a sort of box. A plate is then secu such a way as to oppose a face to the armor plate; this face bein tected by refractory material, so that the molten steel shall not a to it. The distinction between the Brown and Cammell practic that in the former an iron and a steel plate are sandwiched togeth a thin layer of steel poured between them, while in the latter the front of the plate is cast upon the iron backing.

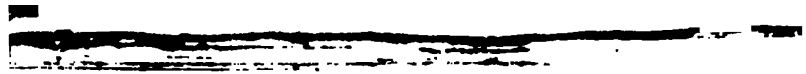
Both methods appear to produce excellent plates. The turrets "Miantonomoh," one of which was seen at Brown's and the oth Cammell's, were satisfactory samples of both practices. The C Works turns out a large amount of steel for general purposes, a manufacture of files is extensively pursued, both by hand a machinery.

Some interesting target practice with heavy ordnance was c out on plates of the foregoing firms in competition with one of Schn at Spezzia, in October of last year. Each plate was 3.050 meters 2.600 meters wide, and 480 millimeters in thickness. The gun use the 100-ton Armstrong, a 43-centimeter B. L. R. Forged steel h

ells of 835 kilograms weight were fired with a charge of 350 kilograms Fossano progressive powder. At the range of 100 meters the striking velocity was 570 meters, the energy of the blow being 4,500 foot tons. The projectiles were shattered by all the plates; but the plates also were broken into five pieces in the cases of the Cammell and the Schneider, and four in that of Brown. The Schneider plate exhibited comparative softness, and an examination of the fragments of the projectiles showed that the one which passed through the Schneider target had been less damaged, though much distorted, by the blow. It was observed, also, that the head of the shell showed only meridional cracks, while in the case of the other two the cracks were of a spiral character, demonstrating that the resistance opposed had been so great that the shot had been conspicuously twisted while passing through the plate. It has been argued that the work required to twist a 43-centimeter shell would inevitably produce ignition of the powder charge before perforation took place, and perhaps prevent complete perforation. The pieces of the steel-faced plate were also wedged widely apart by the action of the shot, while the softer plate was but little separated; indicating that the work done on the latter was mostly absorbed in perforation and that little side action took place.

The Cyclops Works and the Atlas Works are the only firms in Great Britain equipped for making compound armor. There is a pool between the concerns by which the contracts are divided. It may be interesting to the general reader to learn how expensive compound plates are. The British Admiralty pays overhead rates of £75 per ton for the rectangular and shaped plates of a barbette ship and from £90 to £95 per ton for the plates of a turret ship, which necessarily require more work to be done on them on the way of bending and fitting. The plates are furnished drilled and tapped to template and ready to go in place, and very little is done upon them at the dockyards. The latter have ceased to bend plates and are not equipped to bend anything heavier than 12 inches.

Compound plates were definitely adopted by the Admiralty in 1878. "Them "armor," to use the language of Mr. Barnaby, "found a new lease of life," but to their introduction has been ascribed much of the delay in completing armored ships which has evoked such severe criticism from the British press.



DOCKS.

As a subject of interest to the naval architect, although not immediately connected with his profession, the numerous docks met with in Europe seem to call for some remarks. Graving-docks have naturally a stronger claim to the attention of the constructor; but the large basins, with which graving-docks are often associated, which accommodate the shipping of such ports as London, Liverpool, and Glasgow, must have interest for all who are connected with maritime pursuits.

The great rise and fall of the tides about the British Isles has brought to use a system of docks for the loading and unloading of vessels, the necessity of which is not immediately understood by those who have been accustomed all their lives to see vessels discharging and taking in cargoes at the wharves in American rivers and bays. That the inapplicability of our practice to foreign requirements may be fully perceived need only be stated that the rise and fall of the Thames at London Bridge, the head of navigation for sea-borne commerce, is 19 feet; while at Liverpool the variation between high and low water is much greater. The commerce of London and that of Liverpool are nearly of equal magnitude; and the docks of both cities are wonderful networks of basins, which might well engage a more extensive notice than is here contemplated. The docks of Liverpool, taken collectively, are more modern than those of London; and the warehouse accommodation required by the trade of the port is vast, and would take up many pages of description. There are also extensive docks on the opposite side of the river at Birkenhead. There are twenty-eight docks controlled by the Mersey Docks and Harbor Board. The principal are, commencing at the north, the North and South Carriers, the Canada, the Huskisson, Brandon, Wellington, Bramley-Moore, Nelson, Salisbury, Collingwood, Stanley, Clarence, Trafalgar, Victoria, Waterloo, Princes, Georges, Canning, Albert, Salthouse, King's, Wapping, Queen's, Coburg, Brunswick, Toxteth, Harrington, and Herculaneum. These vast works were begun almost a century and a half ago. The great development has, of course, been within the present century. The combined dock estates of Liverpool and Birkenhead now comprise 421 acres of water area, and the quay line measures 18 miles in Liverpool and 9 miles in Birkenhead: 27 miles in all. Amidst these basins are numerous graving-docks; their total bottom length is nearly 15,000 feet.

The abundance and excellence of Portland cement has caused the later docks to be built largely of concrete, and the work throughout bears evidence of the most substantial construction. The new Alexandra docks, recently opened, are particularly well built. The Langton Graving-Docks, also new, are two parallel docks 951 feet in length. They can be divided by gates in the middle, thus making four docks. Cast-iron keel blocks are used, and constitute one of the peculiarities of European practice. They are made wedge shaped and adjustable, and are capped with wood. No bilge blocks are employed, wale shores being mainly relied upon for keeping the vessel upright. The gates are of wood, and are of the swinging type. The bottom of these docks is

crowned and the drainage is to the side. A large hydraulic cra
to be placed between the docks, and work was progressing upo
foundation.

The accompanying sketch will give an idea of the docks in the i
diate vicinity of London. The dry-docks of the Thames are very nu
ous, and of every size, from 140 feet in length on the blocks to 52
A number of them are built of wood, and wooden gates are com
but the principal docks are of masonry or concrete.

The most extensive docks of the Thames are those now in proc
construction at Tilbury, opposite Gravesend, about fifteen miles b
London. I insert a plan of this great improvement, which is bein
ried out by the East and West India Dock Company under the dire
of Messrs. Manning and Baines, civil engineers. Ground was b
in July, 1882, and a vast amount of excavation has been already a
plished and much masonry is in place.

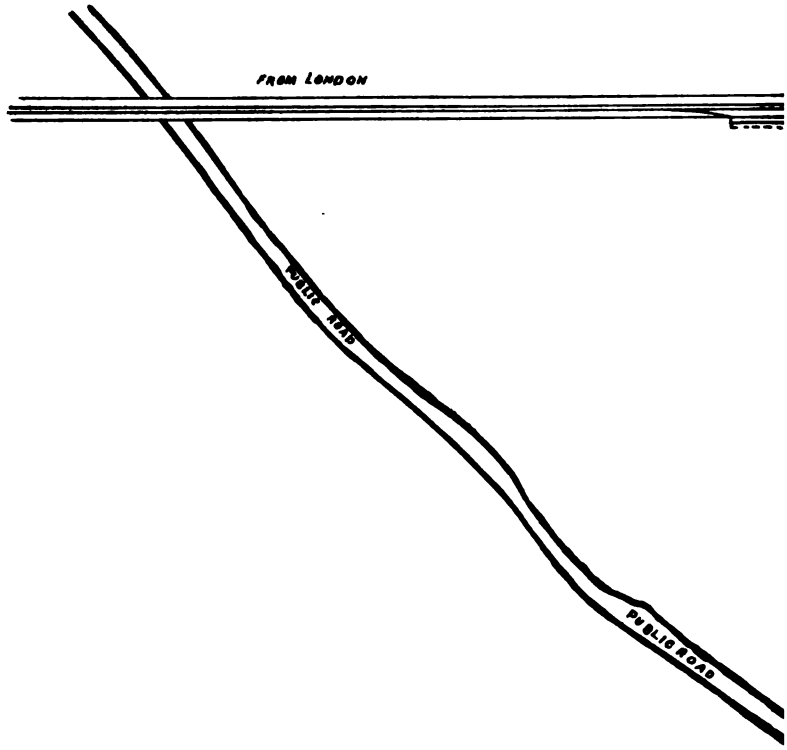
The Tilbury docks will comprise a tidal basin, the entrance to w
will be 100 yards in width. The entrance to the main basin w
through a lock 80 feet in width. The walls are of concrete, faced b
water with stock brick and above with blue brick. The quoins an
are of Cornish granite. The gates of this large lock, which are
made by Clayton & Co., of Preston, are of iron plates. The m
power for opening and closing the lock will be obtained thr
hydraulic mechanism furnished by Sir William Armstrong & Co.
draulic cranes will be arranged to travel along the sides of the q
and are being made by Walker & Co., of Leeds. Four large gra
docks form an important feature of the works. Their walls are of
crete faced with brick, the altars being capped with York stone.
ber coping will run around the dock for facility of introducing eye
wherever they may be desired. The floors will be covered with
pine.

The graving-docks may be filled with water from the tidal bas
from the main dock through culverts. The pumping will be don
centrifugal pumps arranged one to each dock, but so constructed
any pump can lift from any dock. The pumps are very large; two
sections 7 feet in diameter each, and the other two are 6 feet. P
ing will often be economized in the following way: Suppose a ves
No. 1 dock wishes to go out while a vessel lies in No. 4 waiting
docked. The water in No. 4 will be let out as far as the state o
tide permits, and much of the remaining water will be transferr
No. 1 by a system of leveling culverts connecting all the docks
moderate amount of water remaining will then be pumped out.

Both the large and small docks will have three caissons each.
will be three stops for the center caisson, to suit the varying leng
vessels being docked. These caissons are of the boat type. The
shows the warehouses and sheds extending down each pier.
pairs of compound engines, of Armstrong's make, situated at the
end of the docks, furnish the water to the cranes and various hyd
appliances. The hydraulic mains make a circuit of the dock wall

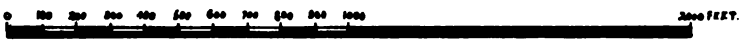
The total area of the outer or tidal basin is 19½ acres. It contai
feet of water at low tide and 46 at high water. The main basin,
sive of the branch docks and the coaling dock, has nearly 23 acre
has a depth of 38 feet. The three branch docks contain 9¼, 9¼, a
acres. These figures sufficiently illustrate the magnitude of the

The city of Glasgow has a large dock accommodation. Greeno
receiving an extensive improvement of the same sort in the James
docks, upon which much progress has been made. Much intere



TILBURY DOCKS.

Scale of Feet.



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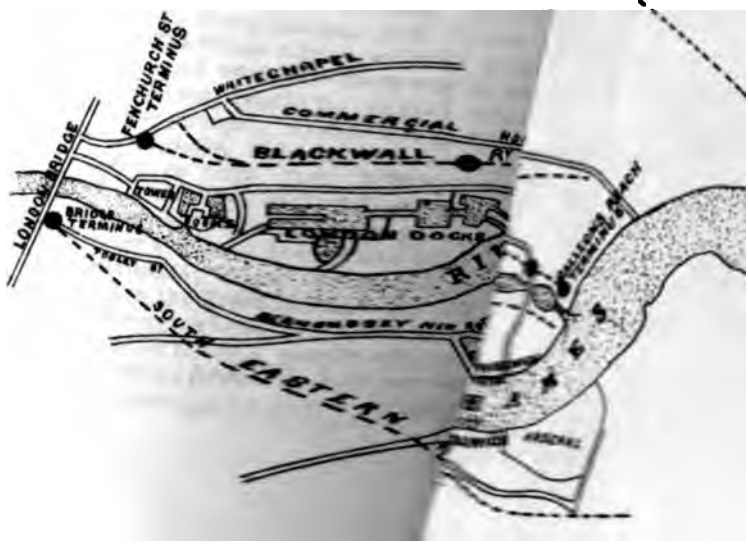

REFERENCE

Stations

Railways

Roads

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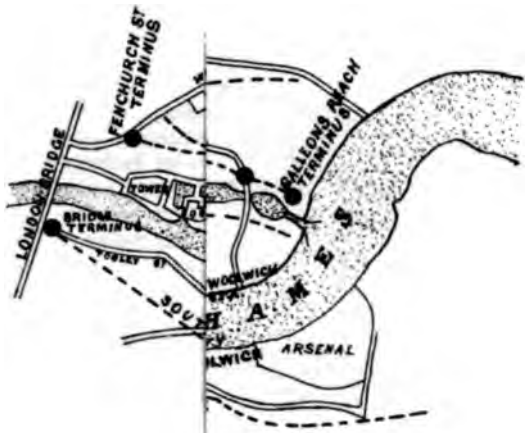

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hes to the sliding caissons invented by Mr. Kinniple, the engineer of
new Greenock docks, as his method certainly simplifies the working
the caisson. In this invention the caisson is a large box or tank,
ich may be filled with or emptied of water, and runs on rollers across
entrance of the dock. When withdrawn it passes into a pocket in
masonry. It may be operated by steam or hydraulic power. In
moderate winter climate of Great Britain it works excellently, but
seems probable that in waters choked by floating ice its performance
ght be less satisfactory.

In London, I had the pleasure of inspecting the machinery constructed
Mr. Allen for pumping the large dock recently built at St. John's,
wfoundland, by Mr. J. E. Simpson, of New York, whose dry-docks
ve met with great approval from the civil engineers and constructors
the United States Navy, and which have a great advantage over the
ving-docks of Europe in cost, light, and accessibility.

There are two centrifugal pumps, having 36-inch suctions, driven di-
tly by two horizontal engines, 21 inches in diameter and 22 inches
oke. They are intended to run at 170 revolutions with 80 pounds
ssure. The combined capacity of the pumps is 6,400,000 imperial
lons in 2½ hours. It may be interesting to state that the total length
this dock, from the outer sill to the inside of the coping at the head
he dock, is 610 feet 10 inches; the breadth across the top is 132 feet
ches; the breadth across the bottom is 49 feet 10 inches; the depth
vater over the sill at spring tides is 25 feet.

Vooden docks cost from 30 to 50 per cent. less than those of stone;
in climates where they are exposed to severe frosts are much cheaper
naintenance; extensive repairs are not required within the first twenty
rs.

CONCLUSION.

The improvements in modern naval architecture are very extensive
m any point we may view them; but in no particular are they more
eresting than in their great variety.
Ships have not only grown in size, structural strength, complexity of
ail, and powers of resistance; but a multitude of other particulars,
h having a distinct offensive and defensive value, have come into
stence in the course of the last quarter of a century.
For many years our ships of war were classed and rated in accordance
th the number of guns they carried, and were sometimes spoken of
ships of three decks, and of two decks, frigates, sloops, brigs, &c.
e mention of any of these descriptions gave a good idea of the powers
the vessel.
Nevertheless the gun classification was, without doubt, the most in-
ligible; and to speak of a ship carrying 80 guns was equivalent to
ying that in fighting power she was superior to a 74.
The weight of a broadside was evidently an illustration of the offensive
pabilities, and many times the variable and undefinable qualities ex-
ing in ships consisted in the bravery and seamanship of the officers
d crew.
Sailing qualities were of great value, especially in frigates; but it is
so true that while some ships were of better model than others, it
as often proven that the speed and maneuvering qualities of a ship
pended many times upon her commanding officer.
Beside the gun scale of classification, that of tonnage was for many
ars very generally adopted in describing the smaller class of vessels;
t since the introduction of steam machinery into our Navy the dis-
acement at the load draught of water is generally used.
Now if a modern ship of war were at all like her predecessors of fifty
ars ago, the displacement would be as good a criterion as could be
ovided to those wishing to be informed regarding her comparative
hting strength. In those days if a naval constructor commenced
th specified dimensions, he would produce, so far as fighting efficiency
concerned, very nearly the same ship as any other naval constructor.
e two vessels would probably carry the same number of guns of
same size, carry the same crew, and have the same area of sail.
hatever differences existed would be found in the form of hull below
ter and in the smaller details of construction. In comparison with
s consider the corresponding circumstances of the present time.
Recently there has been a great controversy between the leading con-
uctors of Europe as to the best manner to utilize 10,000 tons of dis-
acement. In France the naval constructors consider one quality, viz,
ter-line protection, superior to all others; while at the Italian Ad-
alty that quality occupies a very subordinate position in the estima-
n of the constructors. Director of Construction Barnaby, of the Eng-
h Admiralty, takes a mean position between France and Italy; while
r Edward Reed is inclined to go further in that direction than France.
is is, however, only one element which has to be taken in account in
val designs.
The following are some of the principal considerations in war-ship de-
gns: Speed, armor, guns, ammunition, coal endurance, officers and
ew, lightness of draught, torpedoes, torpedo-boats, maneuvering power,

mode of propulsion, ramming, sea-worthiness, sailing power, engine economy, &c. In addition to all these requirements the naval constructor has to build a strong structure, capable of carrying all the weights to be put on board, and to do so on the smallest possible scantlings, in order that his available displacement for guns, arms, &c., may be as great as possible. He has to subdivide his ship into compartments and provide for her safety in every possible manner. Commencing, then, with a given displacement of 8,000 tons, it becomes with him a question of the first importance what he shall do with it.

Shall he carry so much armor as to leave but little buoyancy for carrying machinery and coal? Shall he protect his water-line wholly, partially, or at all with vertical armor?

How far shall he use horizontal submerged armor in order to secure buoyancy when the ship is penetrated? How shall the guns be mounted? What shall be her coal capacity? It is certain that all cannot be obtained that is wanted. Here is where the differences of opinion are sure to arise.

One officer sets a high value on one quality, and another officer upon something else. The result is that at the present time there are nearly as many types as there are ironclads afloat. If the structure were on the land the case would be simple, but as it has to float a compromise must be effected.

Even so-called sister ships differ in some particulars, and each is considered superior by somebody. It is in regard to the results of the continual effort to arrive at the ship of the future that we are chiefly concerned; and we seem so far from having reached a definite result, that some unreasonable people have argued against building any ships at all until some fixed status is attained. Every naval constructor of eminence is responsible for a variety of approximations to the ideal ship; and some of them have produced two or three widely different designs in the course of a year. The process of reaching perfection is an experimental one, and is accompanied by many mistakes.

The lack of important naval battles in recent years stands in marked contrast to the desperate efforts of European powers to equip extraordinary vessels, designed to combine the invulnerable and the irresistable; and to the rarity of great sea fights may be indirectly attributed the superabundance of types; for we cannot but believe that a war of moderate duration, between first-class naval powers, would speedily settle such vexed questions as the utility of the wholly armored water-line versus the citadel ship, and would fix irrevocably the status of such craft as the Esmeralda and the Giovanni Bausan. Such a war would doubtless demonstrate that the elaborate schemes of fleet tactics which have been the theme of many essays by naval officers have been chiefly valuable as a mental exercise; and that, although much importance may attach to a skillful disposition of forces in the beginning of an engagement, yet, in view of the rapidity with which vessels would be disabled by the tremendous means of offense antagonized, and the inability to see or obey signals amid the confusion and obstructing smoke, it is evident that such an engagement must presently become a pell-mell scrimmage.

Such a war, or one such battle, would prove, what has long been the apprehension of intelligent officers, that the warship of our day has become far too complicated for the people who may be called upon to work her; and that a balance of advantage, unsuspected by many, rests with that vessel which has comparative simplicity, even though it be concomitant with a greater apparent exposure of life, a lower speed, and reduced powers of offense.

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